Proceedings of

THE 3rd INTERNATIONAL CONFERENCE OF HYOJEONG ACADEMY 2024

DATE: 1-3, February 2024
VENUE: Online Conference (Peace TV, Korea)

www.lchja.org

The hyojeong academic foundation cordially invites you to the

3rd International Conference of Hyojeong Academy(ICHJA)

Towards the World of Co-Existence Co-Prosperity and Co-Righteousness

About the Event:

The 3rd International Conference of Hyojeong Academy serves as a global platform where researchers and scholars of various disciplines can contribute ideas for our sustainable global community of Co-Existence, Co-Prosperity, and Co-Righteousness. This conference will not only be a venue for exchange of ideas and collaboration among scholars of today but also one to foster the next generation of scholars to join in hand for achieving such global community. In the conference, we will have online/video presentations dealing with religion, science and technology, unification medicine, environment, and more. The 3rd International Conference is scheduled for February 1st-3rd (see the brief schedule below).

Date and Venue:

- DATE: Feb 1(Thu)- Feb 2(Sat), 2024
- Online Conference (Peace TV, Korea)

Organized By:

- Hyojeong Academic Foundation
- Unification Thought Institute International

Conference Chairs:

- Dr. Takahiro Hiroi, Dept. of Earth, Environ. & Planetary Sci., Brown University
- Dr. Chul Hee Han, Unification Thought Institute International
- Dr. Kazuhiro Aoki, Tokoy Medical and Dental University

Brief Schedule:

DAY1-1(Thu) Feb 2024	DAY2-2(Fri) Feb 2024	DAY3-3(Sat) Sep 2024
- 10:30~16:20(Kor. Time) - Registration - Opening Ceremony - Session 1	- 10:30~16:20(Kor. Time) - Congratulatory Speech - Session 5	- 07:20 -09:20: Unification Medical Science Workshop - 11:20~ 14:00: The 30th International Symposium on Unification Thought: East Asian Peace and Unification Thought
- Session 2-4	- Session 6-7	
ZOOM Link https://sunmoon.zoom.us/j/9037027732?omn=88107313766 (ID: 903 702 7732)		ZOOM Link https://sunmoon.zoom.us/j/9143450669?omn=88617303697 (ID: 914 345 0669 / PW: 37230)

For More Information: www.ichja.org / Contact: hyojeong.academia@gmail.com

Collaborators and Supporters

• Sunhak Educational Foundation • Hyojeong Magnolia Medical Foundation • Universal Peace Federation (UPF)

• International Association of Academics for Peace • The Professors World Peace Academy • Sun Moon University

• SunHak Universal Peace Graduate University • Unification Theological Seminary

• Unification Thought Institute International

HJM International Medical Center

Table of Contents

Session 4: African Studies

Session 5: Medical and Health Studies

Session 6: Religious Studies

Welcome Message

Honored scholars, respected delegates, and distinguished guests,

I extend my warmest welcome to each of you at the 3rd International Conference of Hyojeong Academia. As we reconvene under the banner of this prestigious symposium, it is with a sense of pride that we reflect on the success and expansion of knowledge that previous conferences have fostered. We stand together today, not at the inception of a journey, but at a promising continuation of excellence and collaborative achievement.

It is with deep appreciation that I acknowledge each and everyone's contributions and pioneering spirit. Your collective efforts have not only made this event possible but have also extended and enhanced Hyojeong Academia to strive closer toward the ultimate goal of establishing Co-Existence, Co-Prosperity and Co-Righteousness in this troubled world.

This year's conference promises an enriching tapestry of themes, encompassing the vast realms of religion, the sciences, and humanities. We delve into critical issues such as sustainable environmental practices, technological and digital innovation, and equitable technological transfer, all while embracing the essence of our shared human experience through religious and spiritual exploration.

In true Hyojeong spirit—a heart imbued with love and a sense of duty—we continue our pursuit of knowledge that transcends the boundaries between the divine and the empirical. Our assembly here is more than a mere exchange of ideas; it is a collective stride towards a future, where Co-Existence, Co-Prosperity, and Co-Righteousness are not ideals but realities.

As we celebrate the ongoing success of the Hyojeong Academia, I must convey my heartfelt gratitude to the editorial office, the organizing committees, and our dedicated staff, whose exemplary work has been the cornerstone of our conference's continued distinction.

Let us embrace this opportunity to strengthen our partnerships, broaden our horizons, and contribute to a reservoir of wisdom that will empower future generations.

Thank you for your invaluable presence and participation. May our discussions be as enlightening as they are transformative.

Dr. Jin Sung-Bae,
Chair of Hyojeong Academic Foundation

Congratulatory Message

Distinguished scholars, respected guests, and dear colleagues,

I would like to extend a warm welcome to all of you to the 3rd International Conference of Hyojeong Academy. I am Dr. Moon Seong-Jea, the President of Sun Moon University.

My sincere appreciation goes to all esteemed scholars whose unwavering commitment has led to the assembly of this distinguished gathering of intellectual minds.

This conference spans a comprehensive array of disciplines, embracing religion, physical sciences, life sciences, social sciences, and health sciences. The meticulous selection of research themes, incorporating pioneering pursuits in energy, materials, bioscience, technology, health science and many more, underscores our collective dedication to addressing prevalent global challenges. The shared enthusiasm exhibited for the realization of a sustainable community marked by co-existence, co-prosperity, and co-righteousness between academia and society is truly commendable. This shared dedication functions as a cohesive force, strengthening our collective resolve.

It is with great pleasure that I offer special acknowledgment to the editorial office, committees, and staff whose dedication and diligence have been instrumental in orchestrating this event.

As we convene today, it is important to recognize the intricate challenges confronting our world. The rapid progress of modern science and technology, intertwined with deep-rooted societal issues, has given rise to unforeseen issues demanding innovative solutions. The advent of artificial intelligence within the framework of the Fourth Industrial Revolution poses profound questions about human dignity. The displacement of human labor by machines may give rise to a sense of diminished self-worth, leading to disruptions in societal harmony, including increased incidents of violence and substance abuse.

Moreover, the conflicts in Russia and Ukraine, as well as the devastating conflict between Israel and Hamas, signal a potential return to a new Cold War era. Escalating tensions between the Western world, centered around the United States, and socialist states led by China and Russia, along with the global West, amplify concerns. The militarization of vital resources, advanced technology, and the shift away from previously maintained free trade systems towards protectionist trade regimes pose threats to global peace and stability.

In the face of these challenges, it is essential for contemporary academic institutions, particularly the fields represented in this conference – religion, physical sciences, life sciences, social sciences, and health sciences – to assume the pivotal role of nurturing compassionate and empathetic young leaders. These leaders must not only be equipped with the latest knowledge and technological advancements but also rooted in ethical values and a profound understanding of human dignity.

Religion, with its moral compass, must hold the potential to guide humanity toward shared values that transcend individual and cultural differences. The physical sciences, life sciences, and health sciences must contribute to technological innovations and advancements in medical care, ensuring the well-being of individuals and communities. Social sciences provide critical insights into the dynamics of societies, offering solutions for social harmony and inclusivity.

The co-prosperity we seek is not solely economic but also encompasses the prosperity of the human spirit, the health of our societies, and the harmony between humanity and the environment. In this unprecedented era of human history, each academic discipline represented in this conference must play a pivotal role in shaping a future that is sustainable, just, and prosperous for all.

As members of the global community, we shoulder a significant responsibility to harness the combined wisdom from diverse fields in a collaborative effort to address worldwide challenges. This entails fostering interdisciplinary cooperation, cultivating understanding, and expressing appreciation for the contributions from each domain, thereby paving the way toward a more harmonious and prosperous world.

In emphasizing the need for such conferences, it is paramount that we are guided by the foundational principles of love for heaven, love for humankind, and love for the country. Motivated by a collective commitment to humanity and a profound love for the well-being of our world, the 3rd International Conference of Hyojeong Academy provides a unique platform facilitating the convergence of scholars and intellectuals from diverse fields. The principles of love for heaven, love for humankind, and love for the country will serve as a moral compass, guiding us toward a common goal of addressing global challenges through shared knowledge and expertise.

In this context, this conference transcends its immediate academic objective to assume a broader significance. It emerges as a forum where intellectual discourse is not merely an academic exercise but a manifestation of a deeper commitment to the well-being of humanity that reflects the ideals of co-existence, co-prosperity, and co-righteousness.

In conclusion, the 3rd International Conference of Hyojeong Academy not only serves as a venue for scholarly exchange but also plays a vital role in fostering moral responsibility among participants, contributing to a more harmonious and prosperous world.

Once again, I would like to welcome you all to this noble event and wish you all the best.

Thank you.

Dr. Seong-Jea Moon
the President of Sun Moon University

Congratulatory Message

Distinguished Scholars, Scientists, Ladies and Gentlemen:

On behalf of Sunhak Educational Foundation, I am very honored to welcome you to the 3rd International Conference of Hyojeong Academy.

As I understand, the main goal of this conference is to inherit the vision of the International Conference on the Unity of the Sciences (ICUS), which the Reverend Dr. Sun Myung Moon and Dr. Hak Ja Han Moon founded almost 52 years ago.

Despite this conference being held online, I am amazed by 50 researchers from 10 different countries gathered here to share each others' knowledge and move toward the same goal and vision as ICUS.

I hope that you will honor the monumental tradition of ICUS and that the outcome of this Conference becomes a proud addition to the ICUS series.

In this troubled world, we have to strive for Co-existence, Co-Prosperity, and Co-Righteousness, restoring a healthy earth more than ever before, and I am hopeful and inspired by all of you to join this conference to make meaningful contributions toward such goals.

Finally, I want to congratulate a successful conference, and I hope that all of you have an inspiring and productive meeting for the next three days.

May God bless you and your families!

Thank you.

Dr. Yeon Ah Moon
Chair of Sunhak Educational Foundation

Proceedings of
THE 3rd INTERNATIONAL CONFERENCE OF
HYOJEONG ACADEMY 2024

Session 1

Physical and Environmental Sciences

www.lchja.org

3rd International Conference of Hyojeong Academy

Reconstruction of Continental Rifting and Kinematics for the Evolution of Sedimentary Basins in the Ethiopian Rift: Insights from the Afar Region

Duke N. Nyangena, Athanas S. Macheyeki and Seetharamaiah Jagarlamudi*

The University of Dodoma, Dodoma, Tanzania
*Correspondence: nyangenaduke74@gmail.com

Abstract: The Afar region in northeastern Ethiopia is a pivotal area within the East African Rift System, marking the incipient boundary of the Nubia, Arabia, and Somalia plates, resulting in continental breakup and rift formation. The Main Ethiopian Rift, connected to the Afar triple junction, has undergone extensional deformation since the late Oligocene-early Miocene, shaping sedimentary basins and offering insights into crustal dynamics and potential hydrocarbon reservoirs. Despite numerous studies, a consensus on the exact age of rifting initiation remains elusive, with proposed initiation ages ranging from 30 Ma to 15 Ma. This study focuses on establishing the timing of initial continental rifting and trajectory patterns of the Arabian and Somalian plates over the past 65 Ma using Gplates algorithms. Results indicate that rifting between the Arabian and Somalian plates initiated 19 Ma, leading to differential plate motions. The tectonic forces, including the convergence and divergence of plates, have influenced the subsidence and uplift of the region, leading to the development of grabens and horsts within the sedimentary basins, providing valuable insights into the region's geological history and a framework for exploring hydrocarbon resources.

Keywords: Continental rifting, Afar region, East African Rift System, rifting initiation, The Main Ethiopian Rift

1. Introduction

Reconstructing the continental rifting process and analyzing the kinematics involved in the development of sedimentary basins in the Ethiopian Rift, particularly the Afar region, remains a topic that has not received sufficient attention. The Afar region, situated in the northeastern part of Ethiopia within the East African Rift System (EARS), holds considerable geological significance as it marks the initiation boundary of the Nubia, Arabia, and Somalia plates [1]. The Main Ethiopian Rift, a crucial component of the EARS, connects to the Afar triple junction, undergoing extensional deformation since the late Oligocene-early Miocene periods [2,3].

The intricate tectonic activity in this region has played a pivotal role in shaping the evolution of sedimentary basins, providing valuable insights into crustal dynamics and potential hydrocarbon reservoirs [4]. The initiation age of rifting in the East African Rift System has been the subject of extensive study to discern the initiation age, yielding a spectrum of estimates ranging from 30 Ma to 10 Ma, reflecting the elusive nature of consensus in the scientific literature. This study embarks on a comprehensive review, focusing on the timing of the initial continental rifting and trajectory patterns of the Arabian and Somalian plates over the past 65 million years.

Utilizing advanced Gplates algorithms, the work processes finite rotations and geological data to delineate the boundaries of the Somalian and Arabian plates, with the Nubian plate serving as a fixed reference frame. This study not only refines the chronological understanding of rifting but also contributes to a nuanced comprehension of the geological history of the Afar region. The interplay of tectonic forces, including the convergence and divergence of plates, has influenced subsidence and uplift, leading to the formation of grabens and horsts within sedimentary basins. These geological processes provide a foundation for exploring potential hydrocarbon resources and other geological phenomena in this complex and intriguing geological setting.

2. Methodology

The data consists of adapted digitized geometries representing the boundaries of the Somalian plate and Arabian plate, sourced from Gplates geodata, as suggested by [5] along with the pure paleomagnetic reference frame (Nubian plate). The Euler rotations of these tectonic plates that are provided in Table 1 were sourced from [1, 5–

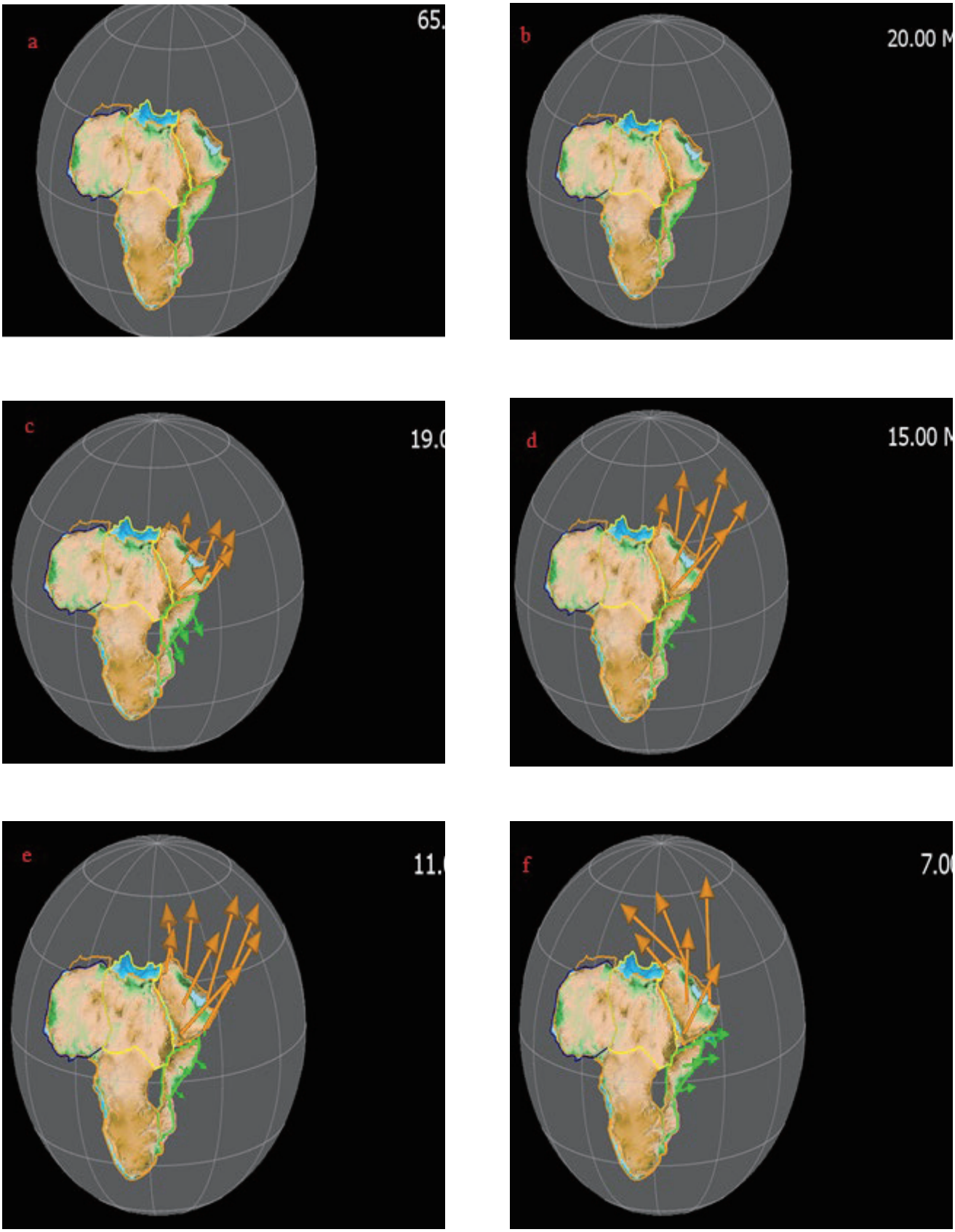
7] [8], [5] and [9]. The digitized geometries and their associated Euler rotations were used to develop the rift model by using the Gplates software downloaded from www.gplates.org. The objective was to offer insights into the dynamics of the Afar region and the convergence and divergence of plates, specifically the Nubian plate and Somalian plate.

Table 1. Finite rotation data from Beyene & Abdelsalam (2005), Iaffaldano & Hawkins (2013), Young et al. (2019) and Fournier et al. (2010b).

Moving plate ID	Age (Ma)	Latitude (°N)	Longitude (E°)	Rotation angle (°)	Fixed plate ID	Plate pair	Reference
503	2.581	23.67	22.21	-0.94	709	Arabia-Somalia	Young et al. (2019)
503	3.596	21.28	28.5	-1.62	709	Arabia-Somalia	Young et al. (2019)
503	6.033	25.46	25.41	-2.4	709	Arabia-Somalia	Fournier et al. (2010)
503	8.769	22.56	27.71	-3.98	709	Arabia-Somalia	Fournier et al. (2010)
503	11.04	23.88	26.66	-4.74	709	Arabia-Somalia	Fournier et al. (2010)
503	15.974	25.85	25.4	-6.85	709	Arabia-Somalia	Fournier et al. (2010)
503	17.533	26.1	22.98	-7.28	709	Arabia-Somalia	Fournier et al. (2010)
503	19.722	26.46	21.66	-7.83	709	Arabia-Somalia	Fournier et al. (2010)
709	2.6	-40.4	39.37	0.17	701	somalia-Nubia	Young et al. (2019)
709	3.6	-38.8	40.01	0.25	701	somalia-Nubia	Young et al. (2019)
709	6	-43.6	43.45	0.4	701	somalia-Nubia	Beyene & Abdelsalam (2005)
709	8.8	-42.4	45	0.6	701	somalia-Nubia	Iaffaldano & Hawkins (2013))
709	11	-43.1	44.29	0.72	701	somalia-Nubia	Iaffaldano & Hawkins (2013)
709	16	-41.3	37.04	0.93	701	somalia-Nubia	Iaffaldano & Hawkins (2013)
709	17.5	-44.4	33.54	0.98	701	somalia-Nubia	Iaffaldano & Hawkins (2013)
709	19.7	-48.9	17.57	1.01	701	somalia-Nubia	Iaffaldano & Hawkins (2013)

3. Results

Figure 1 shows a series of rifting models from Early Paleocene to the Present computed from reviewed data of Beyene & Abdelsalam (2005), Iaffaldano & Hawkins (2013), Young et al. (2019) and Fournier et al. (2010b) (Table 1). The models indicate that between approximately 65 to 20 Ma (Figure 1a-b), there were no observable signs of rifting in the Afar region. Nevertheless, at 19 Ma (Figure 1c), the initiation of rifting in both the Somalian and Arabian plates occurred, leading to their gradual separation from the stable Nubian plate (Figure 1d-h). The Somalian plate and Arabian plates commenced drifting with initial velocities of 1.17 mm/yr and 1.028 mm/yr, respectively (Table 2 & Table 3).


a
65.
b
20.00 M
c
19.(
d
15.00 M
e
11.(
f
7.0(

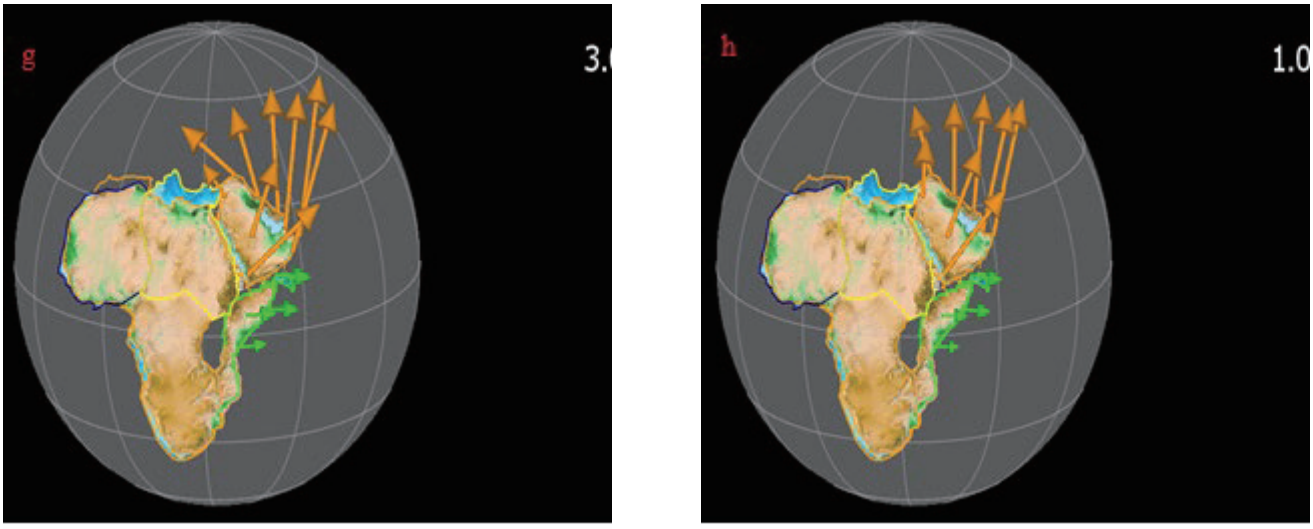
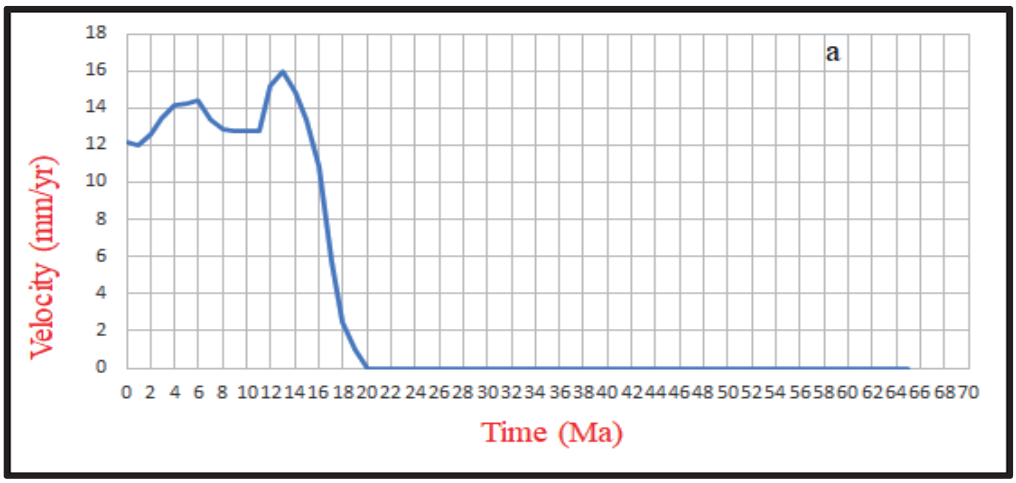


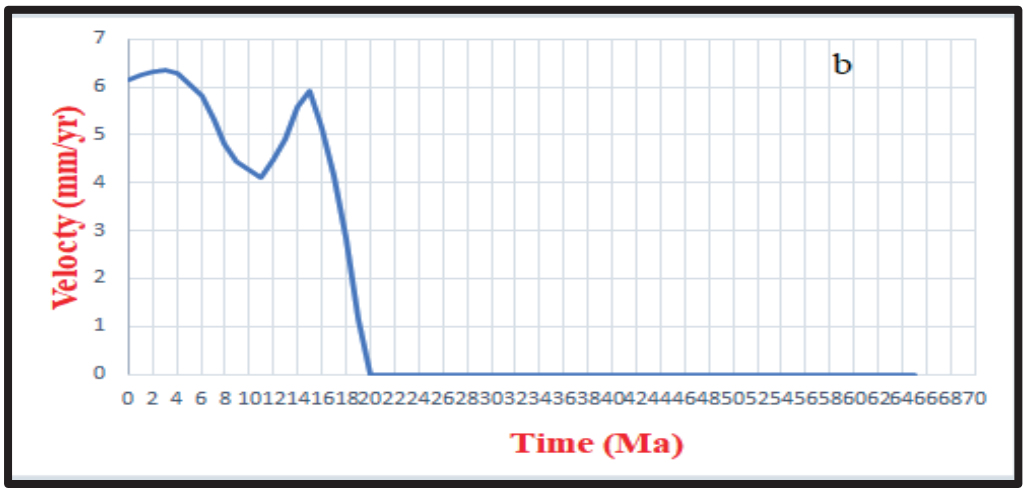
Figure 1. The varying velocity vectors for the Arabian plate (orange arrows) and Somalian plate (green arrows). length of arrows corresponds to the velocity magnitude.

From 19 Ma to ca.13 Ma, the Arabian plate underwent counterclockwise rotation towards the NE direction by approximately 40˚ (Table 2). Between ca. 12 to 10Ma, the plate further rotated to the NNE with a rotation of 2˚ and decelerated as reflected by velocity change from 15.215 mm/yr to 12.742 mm/yr. Subsequently, from ca. 9 Ma to 5 Ma, the Arabian plate underwent a north-northwestward drift, accelerating at a rate of 3.7875 * 10-7 mm/yr2. This acceleration resulted in a change in velocity from 12.746 mm/yr to 14.261 mm/yr, which has persisted from approximately 4 Ma to the Present (Table 2). The plate continued to move in the NNW direction (i.e. towards 343°), indicating counterclockwise movement. Additionally, during the period from ca. 4 to 0 Ma, the plate experienced deceleration of -5.0825 * 10-7 mm/yr2, resulting in a velocity change from 14.164 mm/yr to 12.131 mm/yr (Figure 2a, Figure 1).

Unlike the Arabian plate whose initial trajectory was NE (Figure 3) relative to the Nubian plate, the Somalian plate started to move SSE from 19 Ma to 14 Ma. From 13 Ma to 7 Ma, it changed direction towards the SE with approximately 17˚ rotation. Around 6 Ma ago, the plate began rotating counterclockwise towards the east (Figures 1, 3, Table 3) relative to the Nubia Plate. The first major rifting event for the Somalian plate is inferred between ca.19 Ma and ca.15 Ma, exemplified by plate acceleration of 1.1855 * 10-6 mm/yr2 (i.e. velocity change from 1.17 mm/yr to 5.912 mm/yr within the 4 Ma year's interval). Subsequently, from ca. 13 Ma to 11 Ma, deceleration followed (-4.025 * 10-7 mm/yr2) corresponding to a velocity change from 4.927 mm/yr to 4.122 mm/yr (Table 3). The second acceleration stage took place from ca. 10 Ma to ca.2 Ma, marking the second major rifting event in the region with acceleration value of 2.58375 * 10-7 mm/yr2. The velocity magnitude of the Somalian plate has steadily decelerated with a value of -9.4 * 10-8 mm/yr2, resulting in a velocity magnitude change between 6.236 mm/yr and 6.142 mm/yr over the past 2 Ma until the Present time. Currently, the estimated velocity magnitude of the Somalian plate is approximately 6.142 mm/yr, while the current estimated velocity magnitude for the Arabian plate is 12.131 cm/yr (Figure 2b).



(a)



(b)

Figure 2. (a) Velocity magnitudes of Arabian; (b) Somalian plate. The velocities of both plates have been varying since 19 Ma (the rifting initiation time). At the time of the rifting initiation, the initial velocity of the Arabian plate was 1.028 mm/yr and at ca.13 Ma the velocity reached the highest value of 15.933 mm/yr and significantly dropped to a value of 12.759 mm/yr at 11Ma. The Somalian Plate started drifting with a velocity magnitude of 1.17 mm/yr. Over time, the velocity magnitude increased, reaching its highest value of 6.359 mm/yr at ca. 3 Ma (Compare with Table 2 and Table 3 as well).

Table 2. Modelled velocity magnitudes and azimuths of the Somalian plate

Time (Ma)	Latitude (°N)	Longitude (°E)	Velocity (mm/yr)	Azimuth (°)
65	12.5846	49.7136	0	0
64	12.5846	49.7136	0	0
63	12.5846	49.7136	0	0
62	12.5846	49.7136	0	0
61	12.5846	49.7136	0	0
60	12.5846	49.7136	0	0

59	12.5846	49.7136	0	0
58	12.5846	49.7136	0	0
57	12.5846	49.7136	0	0
56	12.5846	49.7136	0	0
55	12.5846	49.7136	0	0
54	12.5846	49.7136	0	0
53	12.5846	49.7136	0	0
52	12.5846	49.7136	0	0
51	12.5846	49.7136	0	0
50	12.5846	49.7136	0	0
49	12.5846	49.7136	0	0
48	12.5846	49.7136	0	0
47	12.5846	49.7136	0	0
46	12.5846	49.7136	0	0
45	12.5846	49.7136	0	0
44	12.5846	49.7136	0	0
43	12.5846	49.7136	0	0
42	12.5846	49.7136	0	0
41	12.5846	49.7136	0	0
40	12.5846	49.7136	0	0
39	12.5846	49.7136	0	0
38	12.5846	49.7136	0	0
37	12.5846	49.7136	0	0
36	12.5846	49.7136	0	0
35	12.5846	49.7136	0	0
34	12.5846	49.7136	0	0
33	12.5846	49.7136	0	0
32	12.5846	49.7136	0	0
31	12.5846	49.7136	0	0
30	12.5846	49.7136	0	0
29	12.5846	49.7136	0	0
28	12.5846	49.7136	0	0
27	12.5846	49.7136	0	0
26	12.5846	49.7136	0	0
25	12.5846	49.7136	0	0
24	12.5846	49.7136	0	0
23	12.5846	49.7136	0	0
22	12.5846	49.7136	0	0
21	12.5846	49.7136	0	0
20	12.5846	49.7136	0	0

19	12.5346	49.73	1.17	162.2254
18	12.4631	49.7535	2.842	162.1737
17	12.4136	49.7887	4.144	156.7483
16	12.386	49.8354	5.154	149.0267
15	12.3652	49.8667	5.912	145.6843
14	12.3444	49.898	5.593	139.206
13	12.3235	49.9294	4.927	129.1335
12	12.3026	49.9606	4.482	123.503
11	12.2817	49.9919	4.122	124.3811
10	12.2755	50.0397	4.26	118.0449
9	12.2692	50.0875	4.447	112.176
8	12.2663	50.1433	4.825	105.403
7	12.2641	50.2011	5.3	99.4165
6	12.2619	50.2589	5.825	94.4707
5	12.2619	50.3173	6.048	92.9907
4	12.2619	50.3758	6.274	91.6189
3	12.2558	50.4354	6.359	92.2292
2	12.246	50.4913	6.327	93.7808
1	12.2364	50.5443	6.236	95.3462
0	12.2267	50.5973	6.142	97.4581

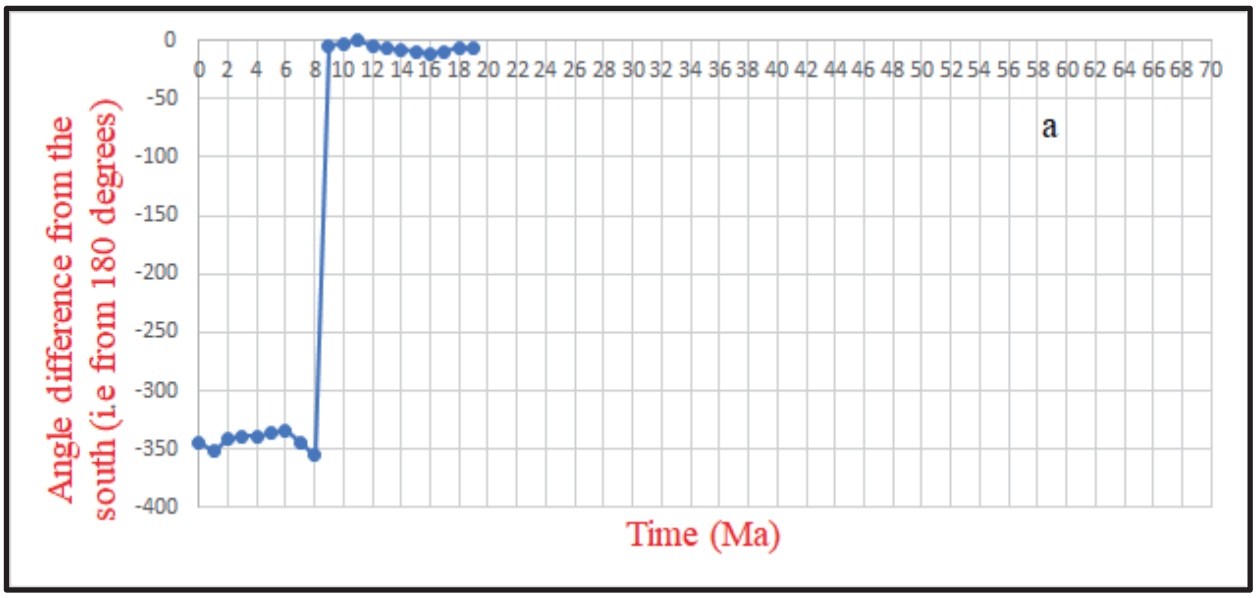
Table 3. Modelled velocity magnitudes and azimuths of the Arabian plate.

Time (Ma)	Latitude (°N)	Longitude (°E)	Velocity (mm/yr)	Azimuth (°)
65	36.4713	42.6845	0	0
64	36.4713	42.6845	0	0
63	36.4713	42.6845	0	0
62	36.4713	42.6845	0	0
61	36.4713	42.6845	0	0
60	36.4713	42.6845	0	0
59	36.4713	42.6845	0	0
58	36.4713	42.6845	0	0
57	36.4713	42.6845	0	0
56	36.4713	42.6845	0	0
55	36.4713	42.6845	0	0
54	36.4713	42.6845	0	0
53	36.4713	42.6845	0	0

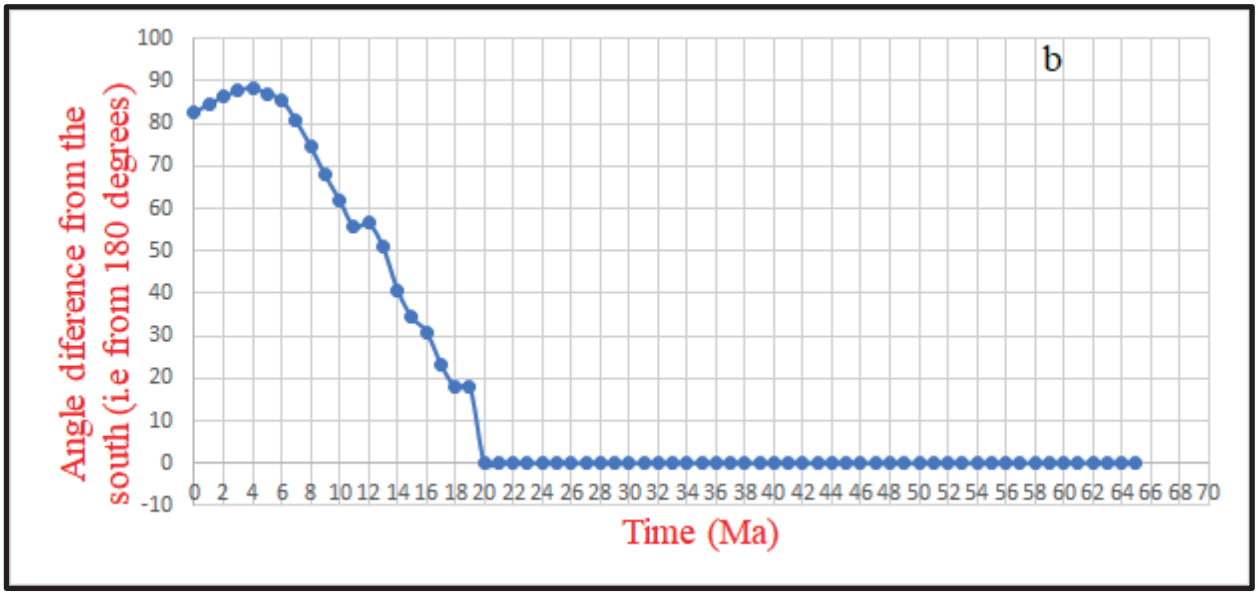
52	36.4713	42.6845	0	0
51	36.4713	42.6845	0	0
50	36.4713	42.6845	0	0
49	36.4713	42.6845	0	0
48	36.4713	42.6845	0	0
47	36.4713	42.6845	0	0
46	36.4713	42.6845	0	0
45	36.4713	42.6845	0	0
44	36.4713	42.6845	0	0
43	36.4713	42.6845	0	0
42	36.4713	42.6845	0	0
41	36.4713	42.6845	0	0
40	36.4713	42.6845	0	0
39	36.4713	42.6845	0	0
38	36.4713	42.6845	0	0
37	36.4713	42.6845	0	0
36	36.4713	42.6845	0	0
35	36.4713	42.6845	0	0
34	36.4713	42.6845	0	0
33	36.4713	42.6845	0	0
32	36.4713	42.6845	0	0
31	36.4713	42.6845	0	0
30	36.4713	42.6845	0	0
29	36.4713	42.6845	0	0
28	36.4713	42.6845	0	0
27	36.4713	42.6845	0	0
26	36.4713	42.6845	0	0
25	36.4713	42.6845	0	0
24	36.4713	42.6845	0	0
23	36.4713	42.6845	0	0
22	36.4713	42.6845	0	0
21	36.4713	42.6845	0	0
20	36.4713	42.6845	0	0
19	36.5172	42.6914	1.028	6.7717
18	36.5827	42.7004	2.496	6.321
17	36.7261	42.7392	5.756	9.4425
16	36.9474	42.8077	10.825	11.2664
15	37.0625	42.813	13.36	9.2298
14	37.1773	42.8172	14.868	7.9255
13	37.2919	42.8204	15.933	6.8894
12	37.4062	42.8224	15.215	4.6892
11	37.5203	42.8234	12.759	0.2779

10	37.6338	42.856	12.742	2.4941
9	37.747	42.8879	12.746	4.7348
8	37.8673	42.7769	12.834	355.6119
7	37.9877	42.6288	13.389	344.1682
6	38.1063	42.4789	14.387	333.913
5	38.2259	42.5464	14.261	336.4317
4	38.3454	42.6134	14.164	338.9943
3	38.4347	42.5118	13.458	338.6713
2	38.5293	42.414	12.63	341.6015
1	38.6416	42.3932	12.01	351.8805
0	38.7533	42.3716	12.131	344.4541

The drifting of both plates were analyzed with reference to the south (i.e. the southern pole) where the angle differences from the south (i.e. 180˚) were determined (Figure 3a, b). From 19 Ma to 8 Ma the Arabian plate azimuth was approximately 6˚, i.e. NNE, making an angle difference with the south of about 174˚ (i.e. 180˚- 06˚). From 8 Ma to the Present, the Arabian plate has rotated in a counterclockwise direction (i.e., from 7˚ to approximately 344). This falls in the NW quadrant (first quadrant), hence the negative sign of the angle difference in Figure 3a. On the other hand, from 19 Ma to 7 Ma, the Somalian plate shows increasing azimuths angle differences with respect to the south pole. From Figure 3b, the angle differences are from approximately 18˚ to about 88˚. However, from 7 Ma to the Present, the plate shows a decreasing angle difference from more than 85˚ to nearly 80˚. Between approximately 5 Ma and approximately 3 Ma, there are insignificant changes in azimuth changes.



(a)



(b)

Figure 3. Angle differences of the plate drifting direction measured from the south (180°) with time in Ma. (a) Arabian plate; (b) Somalian plate. The greater the angle difference, the larger the angle of rotation from the south.

With an exemption of periods between 19 Ma -18 Ma and 12 Ma-11 Ma, the angle difference with time is constantly increasing to the Present meaning that overall, the Somalian plate has been under constant counter clockwise rotation since Early Miocene. A significant clockwise rotation is observed from 4 Ma to the Present meaning that, if the direction of the Somalian plate continues to move in the direction it had in the last 6 Ma, it will be in its original latitude in the next 17 Ma from today. While the Somalian plate presents an open Z pattern motion path, the Arabian plate portrays a motion path that is relatively complex (Figure 3).

Since rifting initiation of the Arabian plate, it maintained an azimuth of N to NNE until around 9 Ma ago, with an average vector direction of 7.5° (i.e., NNE). However, after 8 Ma, there was a drastic change in azimuth, and the plate started moving in the direction of approximately 343° (i.e., NNW). As for the Somalian plate, from 19 Ma ago to 9 Ma, it moved in an average direction of 152.51° (i.e., SSE). However, from 13 million years ago to 7 million years ago, the plate changed its direction to 116° (i.e., SE). From 6 million years ago to the Present, the average vector direction became approximately 99° (i.e., due east). The $\alpha 95$ confidence ellipses, calculated using Fisher statistics in the running mean method, were used to determine average palaeomagnetic poles within a time window of 20 Ma. The ellipses represent a 95% confidence level and accounting for uncertainty associated with the averaged poles. This is in accordance to [10].

4. Discussion

The rifting process that started at 19 Ma resulted in the separation of the Somalian and Arabian plates from the fixed Nubian plate, giving rise to the formation of the East African Rift System. This mechanism of rifting was influenced by factors such as extensional forces and thinning of the lithosphere as explained by [1, 11, 12]. Our computed data reveals that the initial rifting acceleration was higher for the Arabian plate than that of Somalian plate. These significant accelerations are interpreted as major rifting events, likely leading to the formation of large rift basins [13]. The Arabian plate does experience significant angle differences, indicating a relatively large effect of far-field stress and extensional forces associated with rifting. From 8 Ma onwards, the plate started to rotate in a counterclockwise direction, resulting in a negative larger angle difference (i.e. from the NNE to the NNW measured from 180°) that persists up to the Present. Contrarily, the Somalian plate shows smaller angle differences during the initial rifting stage, presumably because the plate experienced relatively minor rotations in its drifting direction compared to its rotation magnitudes at later stages. Episodes of decelerations indicate minor rifting events, suggesting rapid sedimentation within the rift basins [14]. Quiescent periods can be observed for the Somalian plate between 19 to 18 Ma and 11 Ma to 10 Ma, implying calm periods that are likely to

have more rapid sedimentation. The Arabian plate experienced minor rifting periods at 13 Ma to 7 Ma and 6 Ma to 1 Ma.

Over the course of the last 19 Ma, the Somalian plate has traveled a total distance of slightly more than 100 km, whereas the fast-moving Arabian plate has covered approximately twice that distance. The difference in the total distances covered by the Somalian and Arabian plates over the past 19 Ma suggests that the Arabian plate has exhibited a higher rate of plate motion and undergone more significant displacement compared to the Somalian plate. This variation in motion can be attributed to the previously mentioned velocity contrast.

The Arabian plate's faster motion, greater displacement and zigzag motion paths have likely been influenced by the tectonic forces acting on the plate because the Arabian plate exhibits convergence in the north between the Arabian plate and the Eurasian plate [15, 16] and divergent boundaries in the Gulf of Aden [17]. These factors can contribute to both the extensional and compressive stress regimes currently experienced by the Arabian plate within the Gulf of Aden as reported by [18]. The Compressional regimes is attributable to the pushing of the African plate by the Eurasian plate [19, 20] hence its zigzag motion and reduced velocity in the last 8 and 4 Ma, respectively. he compressive forces are responsible for the reduction of the rift basin in the western Gulf of Aden, while greater displacement has resulted in the wider opening and increased number of sedimentary basins in the eastern Gulf of Aden.

Both plates have undergone counterclockwise rotations of about 40° and have maintained nearly orthogonal paths from each other. The Arabian plate moved to the northeast at the beginning, while the Somalia plate initially moved to the southeast. The present movement of the Arabian plate is in the northwest while that of the Somalian plate is due to the east direction suggesting that the Nubian plate is also moving in a counterclockwise direction, meaning that it is currently moving due to the west. The driving mechanism for plate movement in this region is likely from a single source, the mantle plume as the main driving force. Far –field stresses are also adding some effects to the rifting, drifting and motion paths of both plates. The varied movements of these plates have given rise to the creation and evolution of multiple sedimentary basins. The compressive forces in the western Gulf of Aden, coupled with the widening and displacement in the eastern Gulf of Aden, have played a role in shaping sedimentary basins characterized by geological features that vary. The interaction between plate tectonics and far-field stresses is presumed to have played a pivotal role in shaping the sedimentary basins within this dynamic geological environment.

5. Conclusions

Our complementary findings suggest that the rifting in the Afar region started 19 Ma. Immediately after initiation of rifting, drifting of continents occurred. Further, our models show the maximum velocity of the Arabian plate is three times higher than that of the Somalian plate. The Arabian plate is currently moving in the NNW direction, contrary to its initial azimuth of NNE. Similarly, the Somalian plate is currently moving eastward contrary to its initial azimuth of SSE. Major rifting events occurred at ca.15 Ma and ca.3 Ma for the Somalian plate (i.e. a difference of 12 million years), while for the Arabian plate, the major rifting events occurred at ca.13 Ma and ca. 6 Ma (i.e. a difference of 7 million years). These findings indicate that while there were periods of minor rifting, quiescence and sedimentation, each plate was subjected to different tectonic forces with varying magnitudes. The complex counterclockwise rotations of the Arabian plate, suggests that although it is under extensional regime, some compressive stresses are pushing against its general azimuth, leading to the current dominance of a compressive regime in the Gulf of Aden. The tectonic forces, including the convergence and divergence of plates, have influenced the subsidence and uplift of the region, leading to the development of grabens and horsts within the sedimentary basins, providing valuable insights into the region's geological history and a framework for exploring hydrocarbon resources.

Supplementary information: A folder containing snapshots of various models established from data that were reviewed in this work.

Declaration of competing interest: We declare that there are no known conflicting financial interests or personal relationships that could be perceived as influencing the findings presented in this paper.

Acknowledgments: The primary author is sponsored by KFW Bank in collaboration with IUCEA to pursue a Master's degree in Petroleum Geoscience at the University of Dodoma, Tanzania. Gratitude is expressed to Dr. Zahirovic Sabin from Utrecht University for providing continuous technical assistance in data processing software. Ibrahim Omari, a graduate of the University of Dodoma, aided in the calculations of plate motion paths

Authors contribution: DNN conceived the study, obtained and analyzed the data, modeled plate motions, interpreted the findings, and drafted the manuscript. ASM conceptualized the study, interpreted the data, and contributed to manuscript drafting. SJ reviewed and edited the manuscript. All authors participated in the review and editing process.

References

1. Beyene, A., Abdelsalam, M.G.: Tectonics of the Afar Depression: A review and synthesis. J. African Earth Sci. 41, 41–59 (2005). https://doi.org/10.1016/j.jafrearsci.2005.03.003
2. Gani, N.D., Abdelsalam, M.G., Gera, S., Gani, M.R.: Stratigraphic and structural evolution of the Blue Nile Basin, Northwestern Ethiopian Plateau. Geol. J. 44, 30–56 (2009). https://doi.org/10.1002/GJ.1127
3. Stab, M., Bellahsen, N., Pik, R., Quidelleur, X., Ayalew, D., Leroy, S.: Modes of rifting in magma-rich settings: Tectono-magmatic evolution of Central Afar. Tectonics. 35, 2–38 (2016). https://doi.org/10.1002/2015TC003893
4. Roure, F., Cloetingh, S., Scheck-Wenderoth, M., Ziegler, P.A.: Achievements and Challenges in Sedimentary Basin Dynamics: A Review. New Front. Integr. solid earth Sci. 145-233. (2010)
5. Young, A., Flament, N., Maloney, K., Williams, S., Matthews, K., Zahirovic, S., Müller, R.D.: Global kinematics of tectonic plates and subduction zones since the late Paleozoic Era. Geosci. Front. 10, 989–1013 (2019). https://doi.org/10.1016/j.gsf.2018.05.011
6. DeMets, C., Merkouriev, S.: High-resolution estimates of Nubia-Somalia plate motion since 20 Ma from reconstructions of the Southwest Indian Ridge, Red Sea and Gulf of Aden. Geophys. J. Int. 207, 317–332 (2016). https://doi.org/10.1093/gji/ggw276
7. Fournier, M., Chamot-Rooke, N., Petit, C., Huchon, P., Al-Kathiri, A., Audin, L., Beslier, M.O., D'Acremont, E., Fabbri, O., Fleury, J.M., Khanbari, K., Lepvrier, C., Leroy, S., Maillot, B., Merkouriev, S.: Arabia-Somalia plate kinematics, evolution of the Aden-OwenCarlsberg triple junction, and opening of the Gulf of Aden. J. Geophys. Res. Solid Earth. 115, 1–24 (2010). https://doi.org/10.1029/2008JB006257
8. Iaffaldano, G., Rhys, H., Sambridge., Malcolm, A.: Bayesian noise-reduction in Arabia/Somalia and Nubia/Arabia finite rotations since ~20 Ma: Implications for Nubia/Somalia relative motion. Res. Sch. Earth Sci. Aust. Natl. Univ. Canberra, Aust. Cap. Territ. 0200, Aust. 845–854 (2013). https://doi.org/10.1002/2013GC005089.Received
9. Fournier, M., Chamot-Rooke, N., Petit, C., Huchon, P., Al-Kathiri, A., Audin, L., Beslier, M.O., D'Acremont, E., Fabbri, O., Fleury, J.M., Khanbari, K., Lepvrier, C., Leroy, S., Maillot, B., Merkouriev, S.: Arabia-Somalia plate kinematics, evolution of the Aden-OwenCarlsberg triple junction, and opening of the Gulf of Aden. J. Geophys. Res. Solid Earth. 115, (2010). https://doi.org/10.1029/2008JB006257
10. Torsvik, T.H., Van der Voo, R., Preeden, U., Mac Niocaill, C., Steinberger, B., Doubrovine, P. V., van Hinsbergen, D.J.J., Domeier, M., Gaina, C., Tohver, E., Meert, J.G., McCausland, P.J.A., Cocks, L.R.M.: Phanerozoic Polar Wander, Palaeogeography and Dynamics. Earth-Science Rev. 114, 325–368 (2012). https://doi.org/10.1016/j.earscirev.2012.06.007
11. Wright, T.J., Ayele, A., Ferguson, D., Kidane, T., Vye-Brown, C.: Magmatic rifting and active volcanism: Introduction. Geol. Soc. Spec. Publ. 420, 1–9 (2016). https://doi.org/10.1144/SP420.18
12. Michon, L., Famin, V., Quidelleur, X.: Evolution of the East African Rift System from trap-scale to plate-scale rifting. Earth-Science Rev. 231, 104089 (2022). https://doi.org/10.1016/J.EARSCIREV.2022.104089
13. Bosworth, W., Huchon, P., McClay, K.: The Red Sea and Gulf of Aden Basins. J. African Earth Sci. 43, 334–378 (2005). https://doi.org/10.1016/j.jafrearsci.2005.07.020
14. Morag, N., Haviv, I., Eyal, M., Kohn, B.P., Feinstein, S.: Early flank uplift along the Suez Rift: Implications for the role of mantle plumes and the onset of the Dead Sea Transform. Earth Planet. Sci. Lett. 516, 56–65 (2019). https://doi.org/10.1016/j.epsl.2019.03.002
15. McClusky, S., Reilinger, R., Mahmoud, S., Ben Sari, D., Tealeb, A.: GPS constraints on Africa (Nubia) and Arabia plate motions. Geophys. J. Int. 155, 126–138 (2003). https://doi.org/10.1046/j.1365-246X.2003.02023.x
16. Stern, R.J., Johnson, P.: Continental lithosphere of the Arabian Plate: A geologic, petrologic, and geophysical synthesis. Earth-Science Rev. 101, 29–67 (2010). https://doi.org/10.1016/j.earscirev.2010.01.002
17. Gordon, R.G.: The plate tectonic approximation: plate nonrigidity, diffuse plate boundaries, and global plate reconstructions. Annu. Rev. Earth Planet. Sci. 26, 615–642 (1998). https://doi.org/10.1146/annurev.earth.26.1.615
18. Delvaux, D., Barth, A.: African stress pattern from formal inversion of focal mechanism data. Tectonophysics. 482, 105–128 (2010). https://doi.org/10.1016/j.tecto.2009.05.009
19. Grosjean, M., Moritz, R., Rezeau, H., Hovakimyan, S., Ulianov, A., Chiaradia, M., Melkonyan, R.: Arabia-Eurasia convergence and collision control on Cenozoic juvenile K-rich magmatism in the South Armenian block, Lesser Caucasus. Earth-Science Rev. 226, (2022). https://doi.org/10.1016/j.earscirev.2022.103949
20. Reilinger, R., McClusky, S.: Nubia-Arabia-Eurasia plate motions and the dynamics of Mediterranean and Middle East tectonics. Geophys. J. Int. 186, 971–979 (2011). https://doi.org/10.1111/j.1365-246X.2011.05133.x

3rd International Conference of Hyojeong Academy

History of Lunar and Asteroidal Remote Sensing and Discoveries with Their Returned Samples

Takahiro Hiroi [1,2,*]

[1] Department of Earth, Environmental, and Planetary Sciences, Brown University, Providence, Rhode Island 02912, USA
[2] World Research Institute for Science and Technology, https://wristresearch.com
* Correspondence: takahiro_hiroi@brown.edu

Abstract: History of remote sensing studies of the Moon and asteroids changed when lunar samples were returned by the Apollo 11 mission and many meteorites were discovered on Antarctica starting in 1969. Discovery of the isotopic similarity between lunar and terrestrial materials led us to the giant-impact model to form the Moon. In addition, the existence and nature of space weathering were also discovered in 1993 by analyzing the Apollo samples. Another change occurred in 2010 when the Hayabusa spacecraft returned particles of asteroid 25143 Itokawa that proved the identity between many S-type asteroids and ordinary chondrites and the existence of space weathering similar to the Moon. The second sample return from asteroids occurred in 2020 when the Hayabusa2 spacecraft returned samples of C-type asteroid 162173 Ryugu. In spite of some expectations, it was a pristine CI1 chondrite material that was free from terrestrial contaminations suffered by known CI1 chondrite meteorites. The third sample return from asteroids was accomplished by NASA OSIRIS-REx mission, which recovered the greatest amount of samples from asteroid 101955 Bennu. These sample return missions have and will drastically change the accuracy of our knowledge on the composition and surface processes of small bodies and therefore asteroidal remote-sensing researchers will be asked for more accountability as happened to lunar remote sensing studies.

Keywords: remote sensing, sample return, Moon, asteroids, Apollo 11, Hayabusa, Hayabusa2, OSIRIS-REx

1. Introduction

Our very existence highly relies on the special characteristics of the planet Earth, and discovering the origin and evolution of Earth requires studying the Solar System as a whole, which falls into the field of planetary science. Planetary science has been mostly developed through remote sensing of planets and satellites by ground-based, airborne, and space telescopes, and spacecraft missions. Atmospheric compositions of planets are relatively easy to investigate through such remote sensing. However, in order to fully understand the reason why our Earth-Moon system has its current configuration including the sizes, dynamics, and compositions, we really need to study solid samples of planetary bodies. For that purpose, meteorites and interplanetary dust particles (IDPs) have been the only samples of solid planetary materials although they are somewhat altered by the terrestrial environment. In 1969, Apollo 11 mission returned lunar rocks and regoliths as the first recovery of pristine extra-terrestrial solid materials, Japanese Antarctic Research Expedition (JARE) discovered nine meteorites concentrated at the foot of Yamato Mountain Range, and two large carbonaceous chondrites (CCs), Murchison and Allende, fell in Australia and Mexico, respectively. These events allowed researchers to examine many detailed aspects of solar system formation such as elemental, isotopic, and mineral abundances, physical characteristics such as density and porosity, and alterations such as heating, shock, and space weathering. In this paper, outline history of lunar and asteroidal remote sensing and discoveries by their returned samples are reviewed.

2. Moon

Throughout history, the Moon has been the target of imaginations, observations, studies, and exploration. However, the origin and evolution of the Moon had not been clear until Apollo missions returned samples in 1969-1972, which led researchers to confirm the giant-impact hypothesis for forming the Moon [1].

2.1. Lunar remote sensing

Galileo Galilei started observing and sketching the Moon in 1609 [2]. He provided not only evidence that the lunar surface is rough but also how it could be derived even from naked-eye observation that the entire sun-lit surface

is illuminated instead of just a longitudinal line which would specularly reflect sunlight if the surface were totally smooth [3]. It was an example of thought experiments he also used in concluding both heavy and light objects fall at the same speed [4]. Albert Einstein also employed in deriving special and general relativity. Geniuses like them could obtain much more truth from limited facts than ordinary people.

Since then, there were many telescopic observations and spacecraft missions to study the Moon before the first human landing by Apollo 11 mission. While many researchers were lost in identifying the surface composition of the Moon, Bruce Hapke correctly predicted the presence of silicate minerals and space weathering by simulating solar wind with H^+ ions irradiated on basalt powders that altered their photometric, polarimetric, and spectroscopic properties to resemble those of the lunar surface [5, 6]. Unfortunately, his idea of space weathering was not well accepted by the science community at that time, and he redirected his research efforts toward developing a spectrophometric model, which is now well-known as Hapke's model [7]. A bad thing can indeed end up with a good thing.

2.2. Moon-forming hypotheses

There were four hypotheses on how the Moon was formed [8]:

a) Capture: Moon was captured by Earth's gravity as it passed nearby.
b) Accretion: Moon was created along with Earth at its formation.
c) Fission: Earth had been spinning so fast that some material broke away to form the Moon.
d) Giant impact: A Mars-size planet hit Earth, and the debris from this impact formed the Moon.

The accretion and fission hypotheses may not easily explain the difference between the Earth's spin axis and the Moon's orbital axis, the capture hypothesis may result in Earth and Moon having totally different compositions, and the giant-impact hypothesis predicts high compositional similarity between Earth and Moon. Therefore, finding the compositional difference or similarity between Earth and Moon was a key to narrow down the origin of the Moon. Remote sensing alone could not achieve this goal because it would take isotopic analysis of their materials to validate the common origin of two planetary bodies.

2.3. Apollo sample analyses

When the Apollo 11 returned samples were analyzed, their oxygen isotopic compositions were identical to terrestrial materials within analytical errors [9], which confirmed that the giant-impact hypothesis must be the correct origin of the Moon. In addition, when a high-voltage transmission electron microscope (TEM) was utilized to examine submicroscopic-scale composition of Apollo lunar soil particles, nanophase metallic iron ($npFe^0$) particles were found within a thin (100-200 nm) amorphous vapor coating layer [10], confirming the existence of space weathering as Bruce Hapke predicted [6]. Lunar surface became darker and redder through space weathering by solar wind implantation and micrometeorite bombardments over a long period of time. Discovering the products of space weathering ($npFe^0$) took 26 years since Apollo 11 samples were returned until the TEM became available. This is an excellent example that sample return missions allow discoveries by not only the present-day scientists and their techniques but also the future smarter scientists and more advanced techniques.

3. Asteroids

Around the same time when Apollo 11 samples were analyzed, asteroid 4 Vesta was spectroscopically identified as similar to a basaltic achondrite meteorite [11]. This was a confirmation that meteorites could be samples of asteroids and gave hope to identify their parent bodies among asteroids through reflectance spectroscopy. However, very few more pairs of asteroids and meteorites turned out to show spectral matches.

3.1. S-type asteroids and ordinary chondrite controversy

As shown in Fig. 1(a), asteroid 4 Vesta had been the only asteroid whose reflectance spectrum matched with meteorites for a long time since 1970. The main problem was the spectral mismatch between the most common ordinary chondrite meteorites and the most abundant S-type asteroids in the inner main belt. Ordinary chondrites consist of H, L, and LL classes in the order of high to low iron content, and the spectral mismatch is demonstrated in Fig. 1a with Nas LL6 chondrite (black solid line) and asteroid 7 Iris (red filled squares) as examples. If the lunar-type space weathering is occurring on the S-type asteroids, ordinary chondrites could change their spectra to the

S-asteroid spectra. However, there has been no npFe^0 particles or any other type of clear space weathering products discovered in our meteorite collections. Therefore, almost no meteoriticist believed in asteroidal space weathering.

3.2. Pulse-laser irradiation experiments to simulate space weathering

In 1999, a successful space-weathering simulation was performed using pulse-laser irradiation of pressed powder pellet samples of olivine and pyroxene (which are main mineral components of ordinary chondrites) in vacuum [12]. As shown in Fig. 1(b), as the laser energy increases, the ordinary chondrite spectrum became darker and redder to resemble those of S-type asteroids, and npFe^0 particles were discovered in the amorphous vapor coating layer as in the case of Apollo soil particles. This was the first proof that ordinary chondrites could change their reflectance spectra into the S-type asteroid spectra in the same space environment as the Moon. Using these artificially space-weathered olivine and pyroxene spectra, two asteroid spectra were nearly perfectly fit to demonstrate the existence of space weathering on those asteroids [13].

However, in the same manner as happened to Bruce Hapke's H$^+$ iron implantation experiments, many researchers either neglected or attached the above results by Japanese scientists, even to the level of rejecting the author's abstract submitted to the 30th Lunar and Planetary Science Conference (LPSC) in 1999.

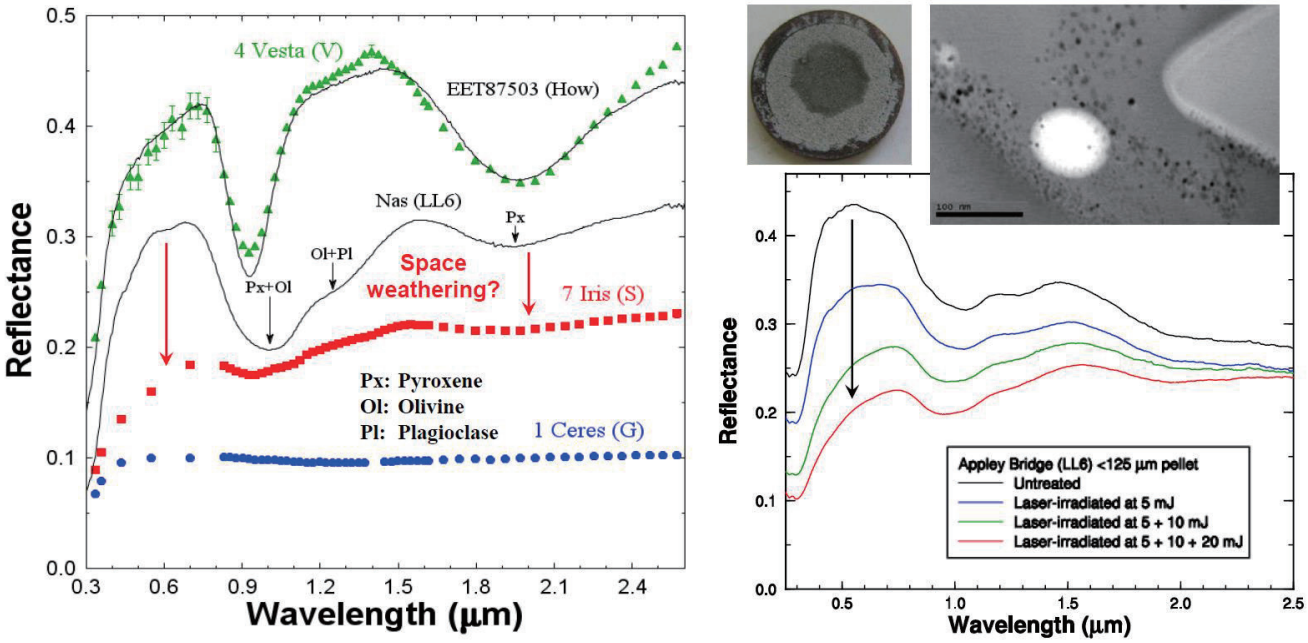


Figure 1. (a) Comparison of visible to near-infrared reflectance spectra of asteroids and meteorites, where telescopic asteroid spectra are shown in colored markers, and laboratory meteorite spectra are shown in black solid lines, and asteroid and meteorite classes are indicated in parentheses. Note that 1 Ceres is now classified as a dwarf planet; (b) Pulse-laser irradiation on a powder pellet sample of Appley Bridge LL6 chondrite meteorite at various accumulated amounts of energy.

3.3. Hayabusa mission returned samples of S-type asteroid 25143 Itokawa

In 2005, Japanese Hayabusa spacecraft rendezvoused with S-type asteroid Itokawa [14], and despite having many accidents and challenges, miraculously returned its sample capsule to Earth in 2010. During the rendezvous phase, the Near-Infrared Spectrometer (NIRS) onboard the Hayabusa spacecraft measured reflectance spectra (0.75-2.1 μm) on many spots of Itokawa surface [15].

Shown in Fig. 2 are modified Gaussian model (MGM) [16] fittings of four representative spots, and Gaussian band center and relative band strength values of a larger number of spots, plotted along with those of ordinary chondrites including Hamlet LL4 chondrite pellet irradiated with pulse laser. In Fig. 2(a), it is clear that all four spectra share almost the same Gaussian band center values with different band strengths and continuum background spectra (broken curves). The continuum slopes indicate increasing degrees of space weathering in the

order of Western Bright Area (blue filled triangles), MUSES-C (green filled squares), and Ohsumi Basin (red filled circles). The close-up spectrum (black asterisk) closed to the MUSES-C spectrum (red filled square) corresponds to about 1 cm size footprint, which signifies that the surface is highly homogenous down to the cm scale, consistent with ordinary chondrite lithology. In Fig. 2(b), it is evident that Itokawa spectra (black filled circles) are most similar to those of LL chondrites (red open circles) and more spectra are similar to laser-irradiated LL chondrite spots (red filled circles). These results indicate that Itokawa is made of LL-chondrite materials and its surface is space-weathered in various degrees, consistent with another study employing Hapke's space-weathering model [17]. Analyses of mostly tiny (~0.1 mm) particles returned from Itokawa revealed these rendezvous phase remote-sensing results were correct [18, 19].

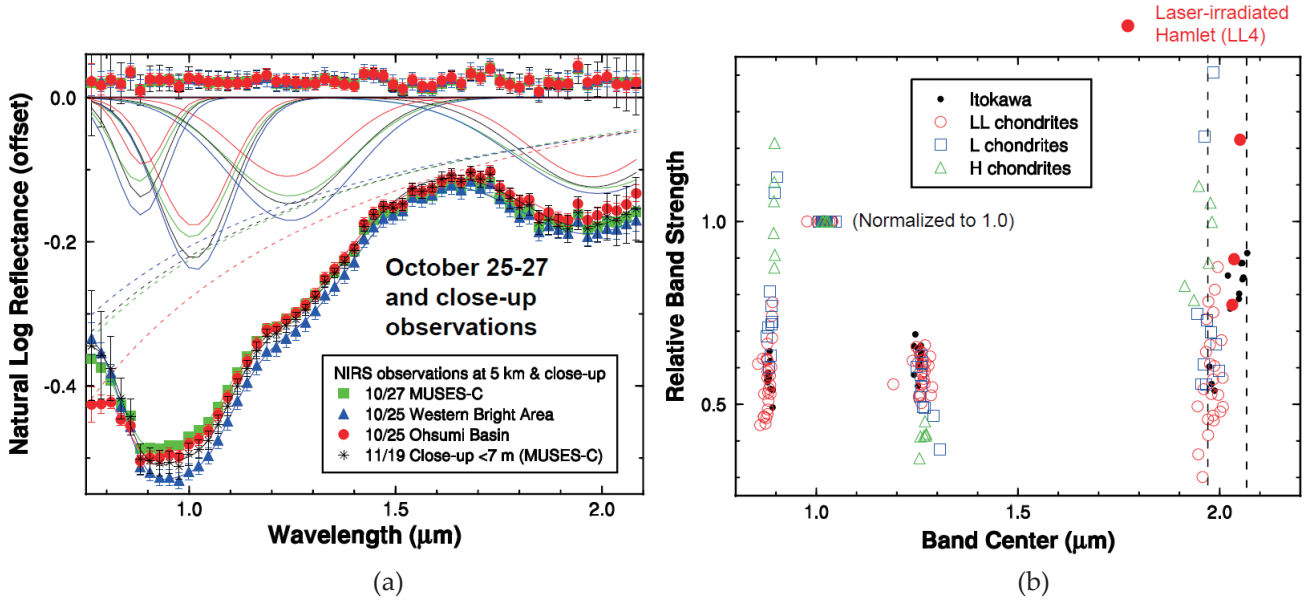


Figure 2. (a) Modified Gaussian model (MGM) fittings of four select reflectance spectra of asteroid Itokawa spots taken by the Near-Infrared Spectrometer (NIRS) onboard the Hayabusa spacecraft; (b) Gaussian band center vs relative band strength of a larger number of Itokawa spectra (black filled circles) plotted along with those of ordinary (H, L, and LL) chondrites including Hamlet LL4 chondrite pellet irradiated with pulse laser (red filled circles).

3.4. Hayabusa2 mission returned samples of C-type asteroid 162173 Ryugu

In 2019, Japanese Hayabusa2 spacecraft landed twice on C-type asteroid Ryugu, and returned its samples to Earth in 2020. During the rendezvous phase, the Near-Infrared Spectrometer (NIRS3) onboard the Hayabusa2 spacecraft measured reflectance spectra (1.8-3.2 μm) of the surface spots to detect hydration features near 2.7 μm, indicating that Ryugu's surface was made of partially dehydrated CI chondrite or shocked CM chondrite material [20]. However, returned Ryugu samples (5.4 g in total) turned out to be pure CI1 chondrite material, totally free of terrestrial contamination, heating, or shock [21]. Also, by comparing the 2.7 μm hydroxyl absorption band position between the returned sample and the NIRS3 data of Ryugu, a 6 nm shift was detected that is evidence of space weathering by solar wind [22].

The reason why the remote-sensing based prediction was incorrect is that the CI1 chondrites in our collections were all contaminated with terrestrial materials or altered by atmosphere or heating, forming secondary minerals. We simple never knew what the true, pure CI1 chondrite spectrum should look like. This situation is illustrated in Fig. 3. Alais CI1 chondrite in our collection shows a much brighter spectrum with features such as UV and broad 3 μm band which are absent in Ryugu sample spectra. On the other hand, Ivuna CI1 chondrite heated at 500 °C shows a much closer spectrum to Ryugu spectra. The probably explanation is that CI1 chondrites in our collection contain terrestrial contamination including iron hydroxides, and heating them in vacuum could remove them.

4. Summary

Lunar sample return by Apollo missions revealed the origin of the Moon and the existence of space weathering. S-type asteroid Itokawa sample return by Hayabusa mission proved that space weathering altered asteroid surfaces with ordinary chondrites hidden among S-type asteroids, and Hayabusa2 mission gave a lesson and a reminder that our CI1 chondrites (and probably some others) are terrestrially contaminated or altered. In order to correctly integrate our knowledge of the Moon, asteroids, and lunar and meteorite samples, space weathering and terrestrial weathering must be evaluated and removed. Another important lesson is that even the world greatest scientists are imperfect, having prejudice against different opinions, etc. We must be obedient to the facts and humbly pursue the truth with unbiased reasoning and imaginations.

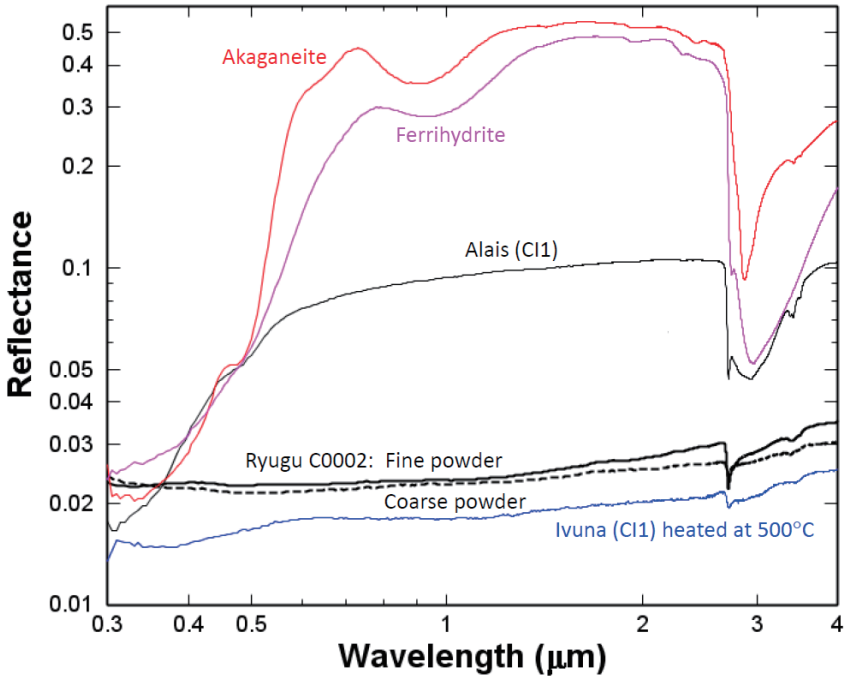


Figure 3. Visible to near-infrared reflectance spectra (0.3-4 μm) of fine and coarse powder samples of asteroid Ryugu [22], powder samples of Ivuna (CI1) meteorite heated at 500°C, of Alais (CI1) meteorite, ferrihydrite, and akaganeite, which are all taken from RELAB database [23].

Funding: This research received no external funding.

Data Availability Statement: Not applicable.

Acknowledgments: RELAB is a multiuser facility supported by NASA PSEF program.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Wikipedia: Giant-impact hypothesis. https:// https://en.wikipedia.org/wiki/Giant-impact_hypothesis (accessed on 11 January 2024).
2. Righini, A. The telescope in the making, the Galileo first telescopic observations. In Proceedings of the International Astronomical Union 6, Padova, Italy (6-9 January 2010).
3. Galilei, G. *Dialogue Concerning the Two Chief World Systems* (1632).
4. Galilei, G. *Discourses and Mathematical Demonstrations Relating to Two New Sciences* (1638).
5. Hapke, B. Optical properties of the Moon's surface. In *The Nature of the Lunar Surface* (Johns Hopkins Univ. Press, 1966).
6. Hapke, B. The composition of the lunar surface inferred from optical properties. *Science* 159, 76-79 (1968).
7. Hapke, B. Bidirectional reflectance spectroscopy: 1. Theory. *Journal of Geophysical Research* 86, 3039-3054 (1981).
8. Lotzof, K. How did the Moon form? https://www.nhm.ac.uk/discover/how-did-the-moon-form.html (accessed on 11 January 2024).

9. O'Neil, J. R. and Adami, L. H. Oxygen isotope analyses of selected Apollo 11 materials. In Proceedings of the Apollo 11 Lunar Science Conference 2, Houston, TX, USA (5-8 January, 1970).
10. Keller, L. P. and McKay, D. S. Discovery of vapor deposits in the lunar regolith. *Science 261*, 1305-1307 (1993).
11. McCord, T. B. et al. Asteroid Vesta: Spectral reflectivity and compositional implications. *Science 168*, 1445-1447 (1970).
12. Yamada, M. et al. Simulation of space weathering of planet-forming materials: Nanosecond pulse laser irradiation and proton implantation on olivine and pyroxene samples. *Earth Planets Space 51*, 1255-1265 (1999).
13. Hiroi, T. and Sasaki, S. Importance of space weathering simulation products in compositional modeling of asteroids: 349 Dembowska and 446 Aeternitas as examples. *Meteoritics and Planetary Sciences 36*, 1587-1596 (2001).
14. Fujiwara, A. et al. Hayabusa at asteroid Itokawa. *Science 312*, 1327-1353 (2006).
15. Abe, M. et al. Near-infrared spectral results of asteroid Itokawa from the Hayabusa spacecraft. *Science 312*, 1334-1338 (2006).
16. Sunshine, J. M., Pieters, C. M. and Pratt, S. M. Deconvolution of mineral absorption bands: An improved approach. *Journal of Geophysical Research 95*, 6955-6966 (1990).
17. Hiroi, T. et al. Developing space weathering on the asteroid 25143 Itokawa. *Nature 443*, 56-58 (2006).
18. Nakamura, T. et al. Itokawa dust particles: A direct link between S-type asteroids and ordinary chondrites. *Science 333*, 1113-1116 (2011).
19. Noguchi, T. et al. Incipient space weathering observed on the surface of Itokawa dust particles. *Science 333*, 1121-1125 (2011).
20. Kitazato, K. et al. The surface composition of asteroid 162173 Ryugu from Hayabusa2 near-infrared spectroscopy. *Science 364*, 272-275 (2019).
21. Yokoyama, T. et al. Samples returned from the asteroid Ryugu are similar to Ivuna-type carbonaceous meteorites. *Science 379*, eabn7850 (2023).
22. Hiroi, T. et al. Evidence of global space weathering by solar wind on asteroid 162173 Ryugu. *Icarus 406*, 115755 (2023).
23. Reflectance Experiment Laboratory (RELAB). https://sites.brown.edu/relab/ (accessed on 13 January 2024).

What does the Universe consist of?

Ivan Chelovekov

Space Research Institute of the Russian Academy of Sciences, Profsoyuznaya Moscow, Russian Federation
Correspondence: chelovekov@cosmos.ru

Abstract: Originally we thought that the whole Universe consists of an ordinary matter as do all earthly things around us. But, with the development of science, we realized that we are also surrounded by force fields and later we understood that both are just different manifestations of energy. Furthermore at the moment we believe that there is more to the Universe than we see. Now we look at the Universe through the prism of 4 fundamental interactions and see baryonic matter in stars, planets, dust and gas, participating in all the interactions, and we see dark matter, participating in gravitational interaction only, and we also see the action of mysterious dark energy occupying over 2/3 of energy balance of the Universe. And now it becomes more and more clear that it is not all to it. Many people fill that physical reality is not the only one and humans also have a spiritual nature that is not yet described by modern science. In this paper I give a short overview of the Universe components as we see it now and underline the importance of making a next step in the scientific development, which will reveal the nature of the spiritual world as well.

Keywords: baryonic matter, dark matter, dark energy, standard model, spiritual world

1. Introduction

Since the very beginning of the human history we are striving for knowledge about the world we are living in. We don't get this knowledge intuitively, but rather use scientific method to acquire it. When we face certain feature of the world, that we don't understand, we start building models of it and testing it. Based on the results of these tests we tune the best working model and state: "That is how the world operates!". But obviously soon or later there always comes a time, when we see some other implementation of this feature which does not fit in our understanding. At first we try not to take it too seriously and blame it on poor quality of the experiment and so it's possible small significance due to poor statistics. But as a number of such situations grows and outstanding results become more and more statistically significant we cannot neglect it any further and we get back to model making. We think of a better, more complicated model, which could not only explain the new observational facts, but should not contradict all the previous observations. In other words we have to get a revolutionary new understanding - dig deeper to reveal a more fundamental model, of which the previous model was just a simple manifestation. One of the best examples of such a situation is the Newtonian physics, which was quite a fine tool all the way while we used it for bodies at low speeds and gravity. But as soon as we come to a more energetic domain, it fails. At this moment some Albert Einstein appears to reveal a deeper model – relativistic physics, which has Newtonian one as its limiting case.

So at this state we are living in the world of models, doomed to endlessly come closer and closer to the true nature of things. Another possibility could be asking the Creator of the Universe, which is simply a one step way, but modern science, based on the scientific method, cannot afford it. It needs to be mentioned that some models become so habitual, that we take it for natural laws and use it in everyday life, ignorant of its incorrectness. Newton laws of motion are a good example. The first law states the existence of an inertial frame of reference (IFR), and the second law as we know it is stated to be valid in any IFR. But as there is no free body in our Universe, IFR can also not be constructed in it and the second law is not applicable. But we are still using it in our everyday life! Why? Simply because in most of the cases the uncertainties we get due to using this wrong model are quite negligible and we need to think of more complicated models only when we deal with more accurate matters. Within this paradigm we can say, that we've been through several revolutions in understanding of what does the Universe consist of, and it seems like another one is at hand!

2. Discussion

2.1. Baryonic matter

Around 25 centuries ago Greek philosophers made a brilliant guess - everything we see when we look around consists of atoms – small indivisible particles. Almost 2.5 millennia later Albert Einstein and Jean Babtiste Perrin proved that Brownian motion of pollen in water is due to water molecules, providing first bricks to the evidence base of this theory. Around the same time sir J.J. Tomson discovers electron [1] and Ernest Rutherford improves his model discovering the existence of atomic nucleus [2], thus revealing a non-elementary nature of atoms. Very soon based on the Albert Einstein and Max Planck quantum theory Niels Bohr offered his model of an atom [3], which with certain improvements is used until now. After following works of Louis de Broglie, Erwin Schrodinger and Max Born we started to regard all the subatomic particles through the glasses of wave-particle duality. In 1919 Ernest Rutherford discovered protons [4] and in 1932 his follower James Chadwick discovered neutrons [5]. It became clear, that atomic nucleus is not elementary either. In 1964 Murray Gell-Mann [6] and George Zweig [7] independently offered a quark model, so now we think that even nucleons (protons and neutrons) are not elementary, but rather they are representatives of hadron family – particles, consisting of quarks. Our modern understanding is that electrons and quarks are elementary, though one cannot even see a solo quark as it only exists in groups (hadrons). We use electrons to make photos of atoms in electronic microscopes and it shows us that we may be on the right path! But as always, when you expand the sphere of your knowledge to some radius R, you get ~R^2 of new unknown frontier, so we now have a lot of unresolved questions in this field and, who knows, maybe it is just a matter of time and corresponding development of our technical abilities and some day we will yet need to broaden our understanding of baryonic matter and go even deeper – to the sub-quark and sub-electron levels.

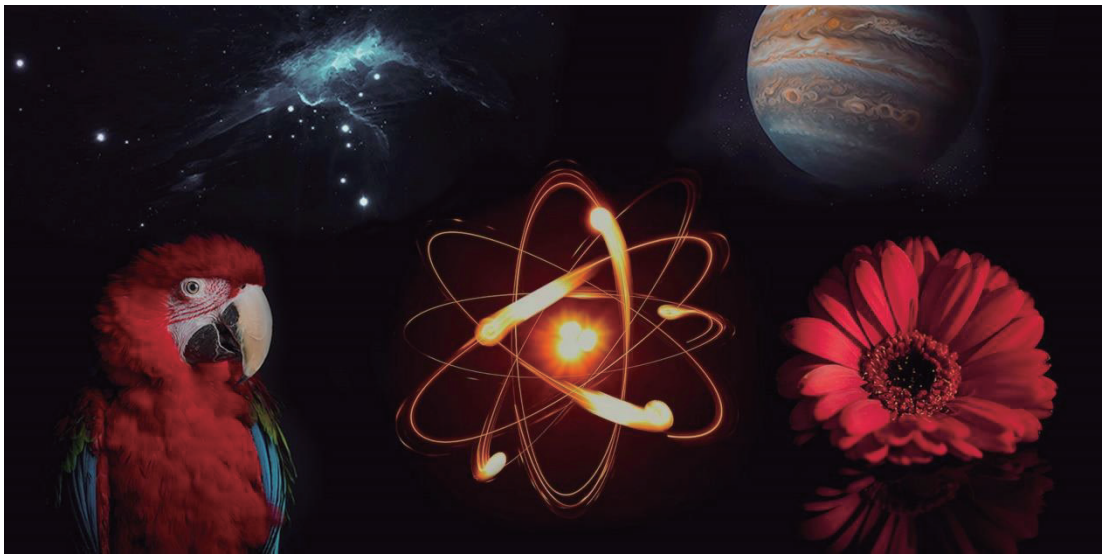


Figure 1. All we see consists of baryonic matter.

So now we understand that any atom consists of a nucleus, containing massive protons and neutrons, and almost 2000 times lighter electrons orbiting the nucleus. Protons and neutrons are baryons, so we can say that all we see around is a baryonic matter (fig. 1). And some might think that the whole Universe is like this - it consists of baryonic matter. How true is this?

It has been thought to be like this for a long time. We can say, that all we see, including planets, stars, interstellar and intergalactic gas - everything that produces or is capable of reflecting electro-magnetic radiation and so be observed does in dead consist of baryonic matter. To describe different elements that constitute this matter we use Mendeleev's periodic table and due to modern developments in astrophysics and other fundamental sciences we now know quite well where and how did these elements come from. Soon after the Big Bang (some microseconds) expansion of the Universe led to its cooling to a state when stable particles like electrons, protons and neutrons could exist, but only 379 000 years later during the primary recombination epoch these could come

together and form H atoms, much less of He atoms and a bit of Li atoms. Some 300 million years later these formed primordial stars, where thermonuclear reactions used these bricks to produce heavier elements up to Fe. After burning all the H fuel in thermonuclear reactions heavier stars went into supernova and even heavier elements were born in their explosions. This way simple H, He and Li multiplied into the whole periodic table. As far as we understand at the moment 88.6% of all baryonic matter atoms in the Universe are H – it is mostly intergalactic and interstellar gas, and a minor part is in stars and other massive astronomical objects. H is a main fuel for main sequence stars, so we can say, that our fuel tank is almost three quarters full and we still have a long way to go as a Universe. Another piece of the baryonic pie is He – these atoms occupy 11.3% of it by number (23% mass wise) and are also present both in the interstellar medium and in stars and other bodies. All the rest of heavier atoms are within 0.1% of the pie by their numbers, which might be a surprise to a non physicist as almost all we see around on the Earth and the Earth itself is made of these heavier atoms – a minority in our Universe!

We describe the Universe in accordance with so called Standard Model, which implies the existence of 4 major interactions – gravitational, electromagnetic, strong nuclear and weak nuclear. The main information channel we use to study the Universe is electromagnetic radiation, consisting of photons – electromagnetic interaction carriers. Protons and electrons possess electric charge so they are capable of such interaction and this makes it possible to see and study baryonic matter all around the Universe (at distances less than 13.8 billion light years). Recently (in 2015) a new info channel was open when a first firm detection of gravitational waves was confirmed, but this channel requires huge masses to move at high accelerations so its application is still very limited.

Around a century ago as it always happened in the history of our science we faced some more features, that we can observe, but cannot explain with the Standard Model. Now it seems that baryonic matter is far not all that constitutes our Universe.

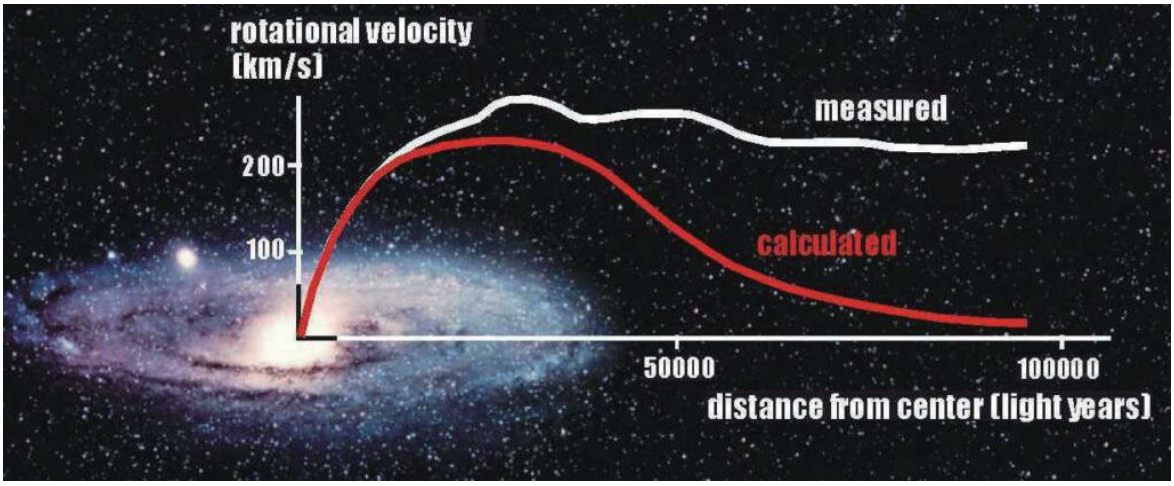


Figure 2. Rotation curve of the Andromeda Galaxy (credit: Queens University).

2.2. Dark matter

From the beginning of the 20th century scientists started to face difficulties in explaining movement of stars in the Galaxy and other galaxies. It is believed, that galaxies are stable systems of gas and stars that stay together due to gravity. Stars and star clusters are moving around the galactic center with tangent velocities determined by the amount of gravitational mass, which is closer to the center then they are. We can use spectral information to determine star velocities and we can estimate the mass of radiating baryonic matter in its galaxy. This gives us a simple way to check whether stars are moving with Keplerian velocities. One after another scientists would come to the conclusion, that stars are moving faster than they are supposed to. Is it the Keplarian law that fails here or there is something wrong with our gravitational mass measurements? It was as far as in 1906 that Henri Poincare came up with a term *matière obscure* (now we call it Dark Matter) for some matter that might be present in galaxies, but not observed. Later Ernst Opik, Jacobus Kapteyn, James Jeans, Jan Oort et al. came to the same conclusion. In 1933 Fritz Zwicky found a huge 1000 km/s spread in radial velocities of 8 galaxies belonging to Coma cluster [8] and after using the Virial Theorem came to the shocking result – for the cluster to be stable its

gravitational mass should be 400 times larger than the mass of its stars! Now we know that this was an overestimation due to the wrong value of Hubble constant that he used, but this and later results highlighted the necessity to search for a new model. In 1939 Horace Babcock published a star rotation curve for Andromeda Galaxy [9] (fig. 2), that clearly showed deviation from the well established Keplerian law – instead of falling in inverse proportion to square root from the distance to the center it rather remained almost constant.

Later in 1982 Jim Peebles assumed that existence of a substantial amount of dark matter may account for a discrepancy between the lack of essential baryonic matter density variations at the primary recombination era and the modern large scale structure of the Universe [10], which could not have been able to develop in such a short time. At the same time the theory of inflation that appeared in 1980s could explain the Cosmic Microwave Background (CMB) radiation isotropy under assumption of critical density of the Universe, which could only be reached with the existence of very significant amount of dark matter, for baryonic matter would only account for a minor part of it.

Up until now the existence of dark matter has been needed to explain not only the galactic rotation curves, dynamics and morphology of satellite galaxies and globular clusters and behavior of multi-galaxy systems. X-ray observations of hot gas in giant elliptic galaxies and clusters witness of its temperatures that are too high to be balanced only due to the visible baryonic matter gravity. Gravitational lensing allows us to see the lack of visible matter in massive galaxy clusters. Finally some observed merging clusters witness of different plasma and main mass distributions in it. These are all hard to explain unless we assume existence of dark matter - a new type of particles, that participate in gravitational interactions but have no connection to electromagnetism, so we cannot see it with our electromagnetic devices. We need it to be there to explain what we see but we do not see it and do not understand what it is, therefore we call it ”Dark Matter”.

2.3. Dark energy

According to our modern understanding of the Universe, it is expanding ever since the Big Bang. It is natural to wonder how is it happening and where will it lead. By the beginning of the 20th century we came to a stage of formulating this question and making first attempts to solve it. In 1915 Albert Einstein formulated his famous equation of gravitational field, that became a foundation of his General Theory of Relativity. Ever since then schientists were tirelessly searching for its solusions in different conditions. When formulated for the Universe as a whole it allowed Alexander Friedmann to invent a cosmological model in 1922 [11], which is, with some improvments, regarded a main stream up until now. Equations within cosmological model allow to predict the dynamics of scale factor, which allows to trace the evolusion of distance between fixed particals in expending Universe. If only baryonic and dark matter are taken into account, equations predict a slowing down expansion, which is obvious and can be easily explained by its gravity. So it became a big surprise, when in late 1990s observations of type Ia supernova led to the opposite conclusion – the Universe seemed to be expanding with positive acceleration. It was accepted (now this issue is a point of argue) that type Ia supernova are standard candles, in other words, they should have the same luminosity where ever they appear. So, if observations show that such an object is deemer, it just means it is further and this is a good needed second prosedure for measuring distance to galaxies in addition to red shift. In this research supernova were deemer than if being situated at distances predicted by the Hubble law, means they were further and this ment that Universe expansion is accelerated. This result was also confirmed by measurements of CMB and gravitational lensing.

The Big Bang nucleosynthesis theory gives a good explanation to formation of such light elements as De, He, Li in the young Universe. Universe large scale theory discribes well forming of stars, quasars, galaxies and galaxy clusters. Both the theories assume that baryonic and dark matter density as around 30% of the critical value. At the same time recent CMB mesurments with WMAP sattelite show, that global space-time curviture of the Universe is indead close to zero, corresponding to a flat Universe and implying overall density to be around critical. But than where do the rest 70% come from?

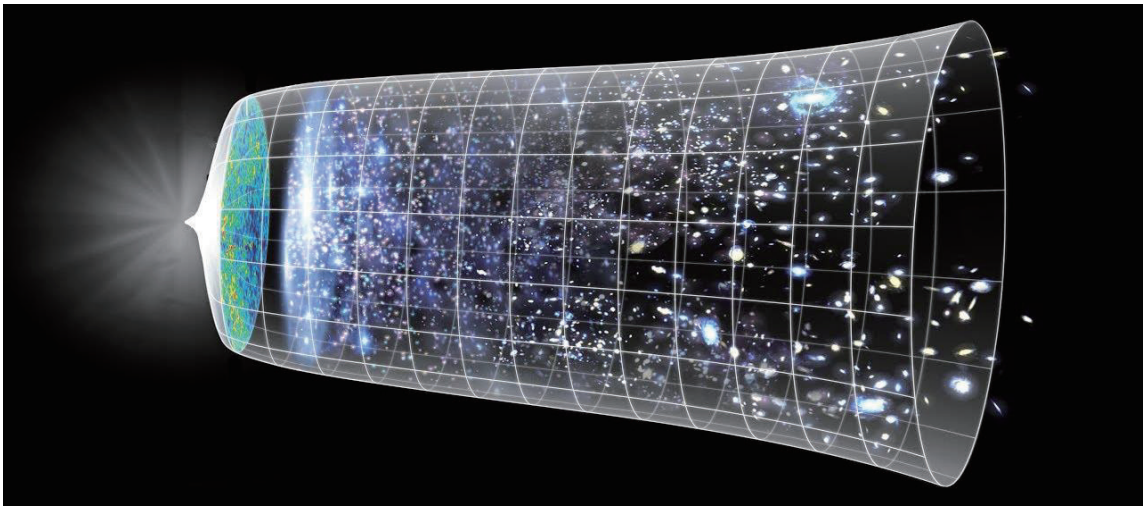


Figure 3. History of the Universe after the Big Bang: 70 000 years of accelerated expansion due to radiation pressure, than around 10 billon years of matter gravity based decelerating expansion and finally almost 4 billion years of accelerated expansion driven by Dark Energy.

These discripancies inspired an introduction of a new entity with negative linar coefficient in cosmological equation of state, which not only accounted for lacking energy density in the Universe, but also could be responsible for its accelerated expansion. Different observational facts agrue this entity should exist, but we do not know what it is and we do not see it directly with our electromagnetic equipment, so, as usual, lets call it Dark something, Dark mater is taken, so let it be Dark Energy - yet another part of the Universe we cannot explain.

Since the end of inflation stage radiation played a dominant role in the evolution of the Universe (fig. 3). About 70 000 years from the Big Bang matter came to rule and it effected the Universe expansion. According to modern astrophysical data interpretation about 4 billion years ago the nature of expansion changed again - it started to accelerate again and we are seeing it now. Unlike Dark Matter Dark Energy does not participate in gravitational attraction and so crowding - it is distributed homogeneously. Density of matter decreases with expansion of the Universe, but density of Dark Energy remains the same, so 4 billion years ago matter density fell below the Dark Energy density and the latter is now ruling the Universe's behavior.

3. Conclusions

So, what does the Universe consist of? Almost 70% of energy density is determined by Dark Energy, around 25% are due to Dark Matter and only 5% consist of baryonic matter (fig. 4). Within these 5% almost 4% represent free H and He in intergalactic and interstellar medium, 0.5% is in stars, 0.3% in neutrinos, 0.03% in heavier chemical elements and 0.01% in radiation. In other words we know almost nothing about 95% of our home Universe and know a bit about the rest 5%.

There is yet another part of our world that science will yet have to explain someday. Throughout the whole human history the vast majority of human beings were believers. There are numerous reports of so called spiritual phenomena in different parts of the world experienced through millennia of our existence. Some efforts were made to find scientific explanations of such phenomena, but they all failed. Some scientists would say that the case is closed and there is nothing to research, but other, including myself, never give up on the path of resolving worlds wonders. Imagine, if we would say: "What we see is all there is", and would not develop observational techniques such as telescopes, optical at first, but then radio, infrared, ultraviolet, X-ray, gamma-ray, gravitational observatories – we would never know the Universe is so huge and various and consists of much more than just several thousand stars one can see at the night sky. Development of science allows us to go deeper in the nature of things in micro world as well as on the Universe-size scales. New ideas, based on deeper understanding of the physical Universe, and state of art accuracy in experiments we achieved today may shed a light on this terra incognita. Understanding of spiritual phenomena, based on the clear and scientific description of the spiritual world, will have to become one of the crucial goals for science in this millennium [12].

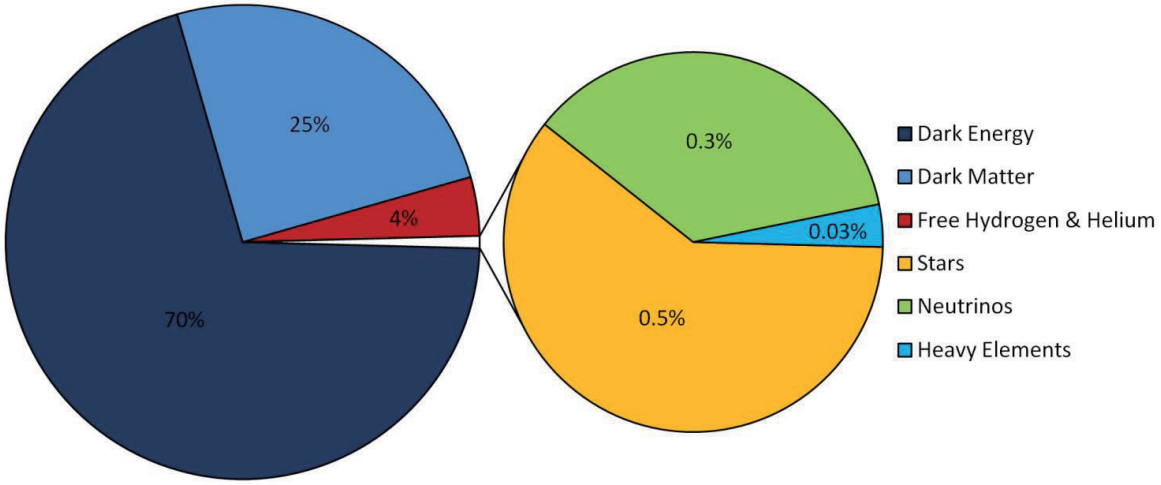


Figure 4. The cosmological composition of the Universe.

This is the reality of today's science and this hints us that we are living in an era on the edge of huge discoveries, when the Standard Model will have to expand to cover 5, 6 or, may be, even 7 interactions, or there may appear another model theory, describing all we know now as a whole in a completely different prospective. One thing is clear: as long as there are unresolved questions, there will always be an indestructible endeavor of human spirit to resolve it and shed the light to the unknown.

References

1. Thomson, J. J. Cathode Rays. *Philosophical Magazine, 44*, 293 (1897).
2. Rutherford, E., F.R.S. The Scattering of α and β Particles by Matter and the Structure of the Atom. *Philosophical Magazine, 21*(6), 669-688 (1911).
3. Bohr, N. On the Constitution of Atoms and Molecules. *Philosophical Magazine, 26*(6), 1-25 (1913).
4. Rutherford, E., F.R.S. Collision of α particles with light atoms. IV. An anomalous effect in nitrogen. *Philosophical Magazine 37*, 581 (1919).
5. Chadwick, J. Possible existence of a neutron. *Nature, 129*, 312 (1932).
6. Gell-Mann, M. A Schematic Model of Baryons and Mesons. *Physics Letters, 8* (3), 214–215 (1964). doi:10.1016/S0031-9163(64)92001-3
7. Zweig, G. An SU(3) Model for Strong Interaction Symmetry and its Breaking. In *CERN Report No.8182/TH.401* (CERN, 1964).
8. Zwicky, F. The Redshift of Extragalactic Nebulae. *Helvetica Physica Acta, 6(II)*, 110-127, (1933)
9. Babcock, H. The rotation of the Andromeda nebula. *Lick observatory bulletin 498*, 41-51 (1939).
10. Peebles, P. J. E. Large-scale background temperature and mass fluctuations due to scale-invariant primeval perturbations. *Astrophysical Journal 263*, L1-L5 (1982). doi:10.1086/183911
11. Friedman, A. Uber die Kr¨ummung des Raumes. *Zeitschrift f˙ur Physik 10*, 377 (1922).
12. Moon, S.M. *Divine Principle, Introduction*, 2nd ed. (HSA UWC, 1973).

An overview of recent environmental disasters due to anthropogenic climate change and its economic impact

Detty Alappat Pathrose* and Lalit Mohan Kukreja

Epi-knowledge Foundation, C2-4/1:3, Sector – 4, Vashi, Navi Mumbai – 400703, India.
*Correspondence: dettyalappatt@gmail.com

Abstract: In the recent past, an unprecedented increase in environmental disasters due to extreme weather conditions around the globe is vindicative that the climate change is no more a myth nor a hoax. As per the reports, recently Earth witnessed the hottest 12 months recorded in human history. The major contributor to this extreme weather condition is global warming caused by fossil fuel burning and other industrial wastes. This extreme weather patterns triggered by human intervention has disturbed the balance of life on Earth, caused large scale severe destruction due to environmental disasters, variations in disease patterns and affected local community cultures. Loss of job hours due to high temperatures may affect the income of individuals, which in turn affects the quality of life and results in a hike in food prices. Riches on earth consume the resources more than their needs. Governments and politicians boast the growth of GDP without any consideration of the environmental debt. Because of the irresponsible way of consuming nature's resources, the tipping point of climate criticality would be inevitable. For the survival and well-being of human kind these environmental destructive practices should be reversed at the earliest.

Keywords: climate change, anthropogenic, global warming, fossil fuel burning, GDP, environmental debt

1. Introduction

The term 'climate change' refers to unprecedented variations in Earth's temperatures due to increases in surface, atmospheric and ocean temperatures which in an aggregated form we refer to as global warming. This global warming is found to have two components, one which is due to the natural thermal cycles and the other is due human activities called anthropogenic climate change. Global warming results in anomaly in local weather patterns [1,2]. These anomalies cause environmental disasters and consequential destructions. As we all know in recent past the number of climate disasters occurring on our home planet Earth have increased in unprecedented number and severity. This is a matter of huge concern for our co-existence and co-prosperity. It is therefore imperative that we understand the details of global warming and find credible solutions to this monstrous problem.

The central question in the wake of above observations is, what causes global warming which results in such devastating climate criticalities. Since the dawn of industrial revolution, energy consumption of human beings increased exponentially, predominantly by burning fossil fuels like coal, oil and gas etc. [3]. These were the sources of energy at that time and even continue to be so in contemporary times. These sources of energy, which are not renewable, are obviously colossal sources of greenhouse gases, mainly oxides of carbon and hydrocarbons. Since these molecules absorb the sunlight and enhance their vibrational energies, those result in global warming. According to climate scientists, for about last 200 years human activities contribute significantly to this global warming. Currently the average surface temperature of the Earth is about 1.2°C warmer than the pre-industrial revolution era [4]. The resultant anomalies in global weather patterns culminate in severe droughts, unprecedented wild fires, catastrophic storms and flooding, thawing of polar ice and glaciers resulting in rising sea levels and declining biodiversity. This vindicates that it is the human activities which is responsible for the climate change and resulting devastating climate criticalities.

Here one may ask a question that if the industrial revolution were not there would we have been in a position to save the human lives at that time, achieved enhanced life expectancy or paved the path for human population explosion? Obviously, the scientific answer is 'no', but the problem is that the industrial revolution also brought about a colossal imbalance in the wealth distribution. A small fraction of the human population became asymmetrically rich compared to the average wealth and resources of human beings. It is this population, which grew over the years and is still growing, started using the resources of mother Earth in a reckless manner. For example,

multiple cars, opulent mansions, private jets, food wastage etc. for a luxurious style of living by the rich caused not only misuse of resources by a small fraction of the humanity but also contributed significantly to the carbon foot print of the world unevenly. We speculate that, even today the carbon foot print by the 80% of the world population of commoners might be only 20% and that by the 20% of rich population of the world might be 80%. Had we used the resources of mother Earth more responsibly and prudently, this situation would not have arrived and perhaps the average increase in the surface temperature of Earth would have been much below the tipping point. In other words, the greed of riches is causing damage to the planet Earth that nature is now unable to reverse.

Besides the riches of the world some of the governments and its politicians are also not behaving responsibly. For their own selfish gains and political ideologies, they do not mind overusing the resources of mother Earth even at the cost of destructions to the delicate ecological systems. Ideally, we should understand that mother Earth is actually one nation and we are its citizens. Therefore, it is our responsibility to live with love and care for Earth beyond the narrow objectives of national divisions. But this world is not an ideal world. Human is the enemy of human. Selfish motives of politicians and their governments perpetuates the policy of divide and rule. This is causing huge loss to our environment and therefore, now the tipping point of climate criticality might be inevitable.

2. Effect of climate criticality on human lives: an overview

The climate criticality is known to affect human lives in a myriad way. Climate change can induce environmental disasters such as floods, droughts, hurricanes and forest fires which directly affect the human population adversely. Climate criticality can also bring about variations in infectious diseases, agriculture and its related ramifications, changes in physical environment and its dietary and mental effects etc. The natural consequences of these climate criticality related issues are loss of life, livelihood and properties etc. According to a recent report by a New Jersey based non-profit organization 'Climate Central', during 2023 about 7.3 billion people all over the world were exposed to extreme temperatures caused by the direct effects of global warming [5]. In this section we present an overview and discuss the effects climate criticality on human lives.

During the last few years, the monsoon pattern in the Indian subcontinent changed drastically causing floods and landslides that affected about 12 million people in India, Nepal and Bangladesh. In the year 2023, the Indian state of Himachal Pradesh witnessed fury of floods and landslides which resulted in the loss of life of nearly 400 people and damage to the property worth billions of dollars. During the summer of 2023 China has seen unprecedented flooding due to abnormal rainfalls and typhoons which battered the country [6]. In 2022, floods in Pakistan devastated nearly one third of its entire area and adversely affected 33 million people. In 2020 the United States of America experienced major wildfire event, severe drought and heatwave conditions, record number of tropical cyclones and tornados and devastating hailstorms [7]. Catastrophic Australian bushfires during 2019-20 scorched an estimated 12.6 million hectares of forests and woodlands. According to 'WWF Australia' report, nearly 3 billion animals were affected in this disaster [8]. Of late there were reports that Greenland glaciers are now melting 5 times faster than 20 years ago due global warming [9].

Climate change is well-known to have effects on human health and diseases. A large fraction of world's population resides in developing countries where health facilities are very poor and climate change may directly impact these people. Among them children, pregnant women, older adults, and people with low incomes are highly vulnerable. Wu et. al. have published an interesting article in 2016 wherein they have shown that climate change makes a significant impact on human infectious diseases [10]. As we know some of the pathogens are carried by hosts or require intermediate hosts to complete their life cycle which has a direct bearing on its transmission. Suitable climate and weather conditions are necessary for their, survival, multiplication and finally transmission of the disease through distribution. Changes in climate and weather conditions are shown to have effects on infectious diseases by affecting the pathogens, hosts and their living environment [11]. Studies have shown that global warming tends to favour the geographic expansion of various infectious diseases. External weather events can help create the possibilities for more outbreaks of clustered diseases which might have geographic and seasonal distributions different from the previous experiences [10]. The intensity of the disease outbreak can also vary due to the unstable climate conditions. This was also observed during the pandemic of covid-19. A more comprehensive study on these correlations and the ways to mitigate the expansion of infectious diseases due to climatic criticalities are expected to come to fore in near future.

As we know agriculture depends heavily on climate and weather conditions. The effect of climate criticality on agriculture is an important area of research and studies because agriculture is the significant source of food for humanity. There can be local and regional variations in agricultural productivity due to extreme weather conditions such as increases in CO_2 level in earth's atmosphere and unpredictability of temperatures and rainfall [12]. Frequent occurrences of wildfires and heat wave conditions are also a potential threat to farmlands and crops. It has also been observed that rising temperature due to climate change has a profound effect on the life cycle and distribution of pests such as weeds, insects, and microbes [13]. In addition, warmer atmosphere and variation in rainfall patterns could alter the time of flowering of crops and the life cycle of natural pollinators like bees, butterflies etc. Any mismatch in the plant blooming and the flurry of pollinators could cause poor pollination and hence less yield. Climate change induced surge in abnormal rainfall conditions and massive floods can cause soil erosion and depletion of plant nutrients from the soil which will affect the plant growth adversely and hence loss of crops [14]. A combined effect of all these phenomena may cause a significant reduction in agricultural yield which raises concerns on global food security, directly affecting the normal life of people [15].

Besides these adverse effects climate criticality is also influencing the ways the local communities live in different in parts of our planet. These are niche areas of climate criticality. For example, in the north Scandinavian region there is a community of indigenous people called Saami. Their culture and the way of living in communion with nature is more than 10000 years old [16]. They heavily rely on reindeer populations for their survival. Due to anthropogenic global warming the Saami inhabitation region called Lapland or Sapmi by Saami's is also significantly affected. It has been reported that average temperature rise in Lapland is about 2.3°C as against the 1.2°C global average [17]. This has resulted in unpredictable snow conditions which in turn has affected their reindeer herding culture and hydrological processes significantly. This has forced many herders to force their livelihood models, for example, some have introduced modern technologies instead of conventional methods in their day-to-day activities and they have started providing additional food to reindeers to survive. The livelihoods that was unique to Saami people is slowly getting lost. This has affected their physical and mental health [18]. The only way for the survival of Saami culture and other similar cultures in the world is to find ways to limit the climate criticality.

3 Climate criticality and economic growth

From the above stated nuances of climate criticality, it is clear that our existence, well-being and prosperity is intimately connected to the climate criticality. The factors such as environmental disasters, human health and agriculture have a direct bearing on the economic conditions of the countries all over the world. The economic health and growth are measured in terms of gross domestic product (GDP) of a country. Bhutan is the only exception which measures gross domestic happiness rather than GDP. Governments calculate their GDP on annual basis but they ignore the environmental debt while calculating GDP. This is unfair because the GDP growth is achieved by the conversion of natural resources into consumables without the consideration of sustainability. Natural resources are finite and their conversion means we are taking it as a debt from the environment meant not only for us but for our own future generations as well. It is therefore important to audit environmental debt while presenting the figures of GDP growth. So far, to the best of our knowledge we did not find any benchmarks for quantifying the environmental debt. We think that economists should figure out how to measure the environmental debt and how to incorporate it in the calculation of GPD to get credible and fair figures. Can it be done by calculating the cost of raw materials extracted from the environment, the cost of managing natural calamities or disasters and the cost of managing diseases and health related issues caused by the professional hazards? Would it be appropriate to deduct all or some of these costs from the amount of the GDP for a particular year before calculating the percentage growth credibly? Fair and credible figures are crucial for determining the correlations between climate criticality and the economic growth. This will provide true solutions to the problem of global warming.

4. Conclusions

In this paper we presented an overview of recent anthropogenic climate criticalities and environmental disasters faced by the humanity on our planet. Billions of people are affected adversely by severe to very severe floods,

forest fires, droughts, heatwaves, infectious diseases, loss of income and agriculture every year. What is the meaning of future if we won't have it due to our own mistakes? It is high time that we should stop damaging the health of air, water and land of Earth. We should convince the rich people to change their ways of living, and also convince politicians and governments to progress responsibly for the survival of humanity and shun their short-term gains for selfish motives. We should motivate all citizens of our planet to live in communion with nature so that we fulfill our needs without greed. If the entire planet dooms due the mistake some, everyone will be doomed including the riches, the politicians and governments, the greedy and irresponsible. We know only one planet as of now where we have the chance to live and survive as a species. If our mistakes make the planet to cross the tipping point and enter into the course of irreversible destruction the chance of living and survival will be lost.

Author Contributions: Both DAP and LMK conceived, contemplated and developed thoughts and prepared the manuscript.

Acknowledgments: We thank Prof. Young Sik Pyun, Sun Moon University, Korea, for introducing us to the Hyojeong Academia and its noble objectives.

Conflicts of Interest: The authors declare no conflict of interest in this paper.

References

1. World Bank Group Climate Change Knowledge Portal: What is Climate Change? https://climateknowledgeportal.worldbank.org/overview (accessed on 18 October 2023).
2. Energy Education: Natural vs anthropogenic climate change. https://energyeducation.ca/encyclopedia/Natural_vs_anthropogenic_climate_change (accessed on 18 October 2023).
3. Wrigley, E.A. Energy and the English Industrial Revolution. *Phil. Trans. R. Soc. A. 371,* (20110568) 1-10 (2013).
4. United Nations Climate Action: What Is Climate Change? https://www.un.org/en/climatechange/what-is-climate-change (accessed on 18 October 2023).
5. Wong C. Earth just had its hottest year on record - climate change is to blame. *Nature 623,* 674-675 (2023).
6. Center for Disaster Philanthropy: 2023 China Floods. https://disasterphilanthropy.org/disasters/2023-china-floods/ (accessed on 10 November 2023).
7. National Oceanic and Atmospheric Administration: Record number of billion-dollar disasters struck U.S. in 2020**.** https://www.noaa.gov/stories/record-number-of-billion-dollar-disasters-struck-us-in-2020 (accessed on 22 November 2023).
8. WWF Australia: In-Depth: Australian Bushfires. https://wwf.org.au/what-we-do/australian-bushfires/in-depth-australian-bushfires/ (accessed on 22 November 2023).
9. UCAR Center for Science Education: Greenland's Ice is Melting. https://scied.ucar.edu/learning-zone/climate-change-impacts/greenlands-ice-melting (accessed on 14 December 2023).
10. Wu, X., Lu, Y., Zhou, S., Chen, L. and Xu, B. Impact of climate change on human infectious diseases: Empirical evidence and human adaptation. *Environ. Int. 86,* 14 -26 (2016).
11. Epstein, P.R. Climate change and emerging infectious diseases. *Microbes Infect. 3*, 747-754 (2001).
12. Mall, R.K., Gupta, A. and Sonkar, G. Effect of Climate Change on Agricultural Crops. In *Current Developments in Biotechnology and Bioengineering: Crop Modification, Nutrition, and Food Production* (Elsevier, 2017).
13. United States Environmental Protection Agency: Climate Change Impacts on Agriculture and Food Supply. https://www.epa.gov/climateimpacts/climate-change-impacts-agriculture-and-food-supply (accessed on 23 December 2023).
14. Ziska, L. et al. Food safety, nutrition, and distribution. In *The impacts of climate change on human health in the United States: A scientific assessment*. (U.S. Global Change Research Program, 2016).
15. Chakraborty, S. and Newton, A. C. Climate change, plant diseases and food security: an overview. *Plant Pathol., 60*, 2-14 (2011).
16. The University of Texas at Austin: The Early Period of Sámi History, from the Beginnings to the 16th Century. https://www.laits.utexas.edu/sami/dieda/hist/early.htm (accessed on 5 January 2024).
17. National Oceanic and Atmospheric Administration: Human-caused climate change fuels warmer, wetter, stormier Arctic. https://www.noaa.gov/news-release/human-caused-climate-change-fuels-warmer-wetter-stormier-arctic (accessed on 5 January 2024).
18. Jaakkola, J.J.K., Juntunen, S. and Näkkäläjärv, K. The Holistic Effects of Climate Change on the Culture, Well-Being, and Health of the Saami, the Only Indigenous People in the European Union. *Curr. Environ. Health Rep. 5*, 401-417 (2018).

Proceedings of
THE 3rd INTERNATIONAL CONFERENCE OF
HYOJEONG ACADEMY 2024

Session 2

Bio Science

www.lchja.org

Insight into the therapeutic potential of Antarctic mosses: A metabolic profiling approach

Kristina Lama[1], Ryoichi Yamada[1], Hirotake Yamaguchi[1] and Tae-Jin Oh [1,2]*

[1]Department of Life Science and Biochemical Engineering, Sun Moon University, Asan 31460, Korea
[2]Genome-based BioIT Convergence Institute, Sun Moon University
*Correspondence: tjoh3782@sunmoon.ac.kr

Abstract: Over the course of history, plant materials have been utilized for healing various ailments. The knowledge derived from traditional medicine has proven invaluable, serving as a foundational resource for drug discovery and design. However, the journey from screening natural products to the development of drugs is a prolonged and demanding process. Fortunately, with the emergence of sophisticated analytical techniques and the establishment of global databases containing information on thousands of natural products, the screening and discovery of bioactive compounds from complex sample mixtures have become more time-efficient and less labor-intensive. In particular, the non-targeted metabolomics approach proves advantageous, offering a comprehensive analysis of a wide range of compounds, aiding in the detection of both known and unknown substances. This approach is especially beneficial for gaining a thorough understanding of the pattern of metabolites found in Arctic and Antarctic vegetation, among the least explored areas on Earth. Here, we employed a non-targeted metabolic profiling approach to analyze the chemical components in Antarctic mosses. While many of the compounds could not be predicted, some were identified as therapeutic agents, with a few exhibiting pharmacological properties such as anticancer, anti-inflammatory, antilipemic, anti-diabetic, anti-adepogenic, and neuroprotective effects. Notably, we predicted that one moss sample produced Desulfiram, an FDA-approved drug for the treatment of alcohol dependency, and methyl palmitate, well-known for its anti-inflammatory potency, could be detected in many of the samples. Furthermore, we experimentally verified the therapeutic potential of Antarctic moss extracts by conducting a cyclooxygenase-2 (COX-2) inhibition assay, assessing their potent anti-inflammatory activity. Indeed, two of the moss samples exhibited significant COX-2 inhibitory potency. Hence, our findings emphasize the advantage of metabolic profiling in providing insight into the potential of Antarctic moss as a valuable natural resource for the discovery and development of potent therapeutics. Additional research is due in order to identify and define the particular bioactive compounds accountable for the observed effects.

Keywords: Antarctic mosses, non-targeted metabolomics, metabolites, pharmacological properties, COX-2 inhibition.

1. Introduction

Indigenous knowledge, traditional medicine, and ethnopharmacology have forged a rich foundation for the discovery of therapeutic agents [1]. The wealth of information embedded in the wisdom of diverse cultures and centuries-old practices, often rooted in the use of local flora for medicinal purposes, has set the stage for unlocking the latent potential of nature's pharmacy [2,3]. Even though use of natural products (NPs) for medicinal purposes dates to 2600 BC [4], till now the chemical space of yet to be discovered NPs still outweighs the known [5,6]. This setback could be due to high cost, time consuming and labor-intensive applied methods [7]. However, recent advancements in computing and information processing keep us hopeful as we can systematically explore uncharted territories for potential drug candidates by harnessing the power of high-throughput screening processes [8]. The rapid analysis of vast datasets across available databases of natural products will expedite the identification of promising compounds from untapped resources [9].

Metabolomics refers to the comprehensive measurement of all metabolites and low-molecular-weight molecules in a biological specimen. And metabolic profiling is the systematic analysis, identification, and quantification of metabolites within a specific biological system [10]. Both processes are valuable for understanding the complex metabolic processes and their respective metabolites. Based on the approach two types of metabolomics can be applied, targeted and non-targeted. As the name suggests, non-targeted metabolomics encompasses the global measurement of all metabolites in a sample, including both known and unknown targets [11]. Utilizing

analytical techniques such as mass spectrometry, non-targeted metabolic profiling offers high-throughput screening of compounds [12].

Integrating metabolomics for the exploration of Antarctic mosses emerges as a captivating frontier in drug discovery. These resilient organisms, thriving in one of the harshest environments on Earth, hold the promise of unique bioactive compounds [13]. By applying a metabolic profiling approach, we can delve into the intricate biochemical pathways of Antarctic mosses, unraveling their therapeutic potential. The vast natural product database, cultivated through the amalgamation of traditional knowledge and computational screening, serves as a reservoir of information to guide this exploration.

Therefore, this study carried out the exploration of the less studied resource Antarctic mosses leveraging analytical techniques, computational tools and database searching (metabolic profiling) to unravel their therapeutic potential. Furthermore, experimental evaluation was performed where the moss extracts were assessed for their bioactivity using COX-2, an enzyme involved in inflammatory response in the body [14].

2. Materials and Methods

2.1. Chemicals

Solvents used for extraction such as methanol and acetone were purchased from Daejung Reagents Chemicals (>99.8%) and Samchun Pure Chemicals (99.7%) respectively. HPLC grade solvents were used for Ultra-High Performance Liqiuid Chromatography (UHPLC) bought from Fisher Scientific, Korea. A COX ovine/human Inhibitor Screening Assay Kit 560131 (Cayman Chemical, Ann Arbor, MI, USA) was used.

2.2. Moss sample processing and extraction

Moss samples were obtained from the Polar Natural Product Chemistry Laboratory of the Korea Polar Research Institute. Processing involved grounding of the dried samples in a mortar, weighing about 3 g of the powdered sample and distribution into each flasks. The flasks were filled with (200 mL) acetone and extracted at dark and room temperature condition for 24 h with constant stirring. The mixture was filtered, and the filtrate extracts dried under reduced pressure. The process was repeated thrice and after the third extraction, the solvent was replaced by methanol and the process continued as before. In this way, acetone and methanol extracts for each moss samples were obtained. The dried crude extracts were dissolved in HPLC grade methanol for futher analysis.

2.3. Metabolic profiling

2.3.1.UHPLC analysis

Preliminary analysis of metabolites was conducted on a Shimadzu Nexera UHPLC system equipped with a Shimpack GIS C18 column (4.6 X 250 mm, particle size 5 μm HSS) connected to a Photo Diode Array (PDA) Detector. The mobile phase consisted of two solvent system, solvent A consituting of water and solvent B, acetonitrile. The elution method followed a gradient flow starting off at 5% solvent B reaching 100% at 28 min. The flow rate was maintained at 1.0 mL/min.

2.3.2. LC-MS/MS analysis

A Thermo Scientific UHPLC, Ultimate 3000 RSLC System coupled to a Q-Exactive Plus Orbitrap mass spectrometer was used for untargeted LC-MS/MS. Chromatographic separation in the LC system carried out using Acquity UPLC BEH C18 column (2.1 X 100 mm, 1.7 μm) with two solvents water (C) and acetonitrile (D), both acidified with 0.1% formic acid. The gradient elution method was as follows: 5% D (2 min), 5-100% D (2-9min), 100% D (9-13min), 100-5% D (13-13.1 min), 5% D (13-16min). the column temperature was maintained at 50°C, injection volume of 5 μL and flow rate of 0.4 mL/min. Mass spectra were recorded in full MS-ddMS2 positive mode at the range of 80-1000 m/z. The operation parameters were as follows: collision-induced dissociation energy: 30 V, resolution: 70,000 for full MS and 17500 for ddMS2, ion spray voltage: 3.5 kV, capillary temperature: 370°C. The Raw MS data files were searched against databases such as High-Resolution Accurate Mass (HRAM), MassList, ChemSpider, etc. and matched spectrums annotated.

2.4. Raw data processing and molecular network building

Futher analysis of the raw data was performed as described previously [15,16] with some modifications. Briefly, the raw files were convert into a suitable "mzML" format. For molecular network building, Global Natural Product Social (GNPS) (https://gnps.ucsd.edu/ProteoSAFe/static/gnps-splash.jsp) molecular networking platform was utilized. The coverted files were uploaded into the GNPS site through WinSCP software. Another platform, SNAP-MS (www.npatlas.org/discover/snapms), processed the network generated from GNPS, annotating the subnetworks. The resulted files were downloaded as a graphML network file and visualized in Cytoscape (http://cytoscape.org/).

2.5. COX-2 inhibition asssay

In-vitro COX-2 inhibition assay was carried out using COX (ovine/human) Inhibitor Screening Assay kit from Cayman Chemical following the instruction in the manual provided. The tested concentrations were 50 and 500 µg/mL. Postive control contained only DMSO. For negative control, the enzyme was subjected to thermal denaturation. Data were reperesented as the percentage of control.

2.6. Statistical analysis

Experiments were performed in triplicate and the results were expressed in terms of mean ± standard deviation.

3. Results

3.1. Preliminary analysis of metabolites

Reversed phase HPLC of the crude extracts of Antarctic mosses showed multiple peaks in the chromatogram indicating the presence of diverse range of compounds with varying polarity. Figure 1 shows chromatogram of MS-10 and MS-13 acetone and methanol extracts with solvent blank as methanol. Indicated by red arrows, distinct peaks may be unique components of the extracts.

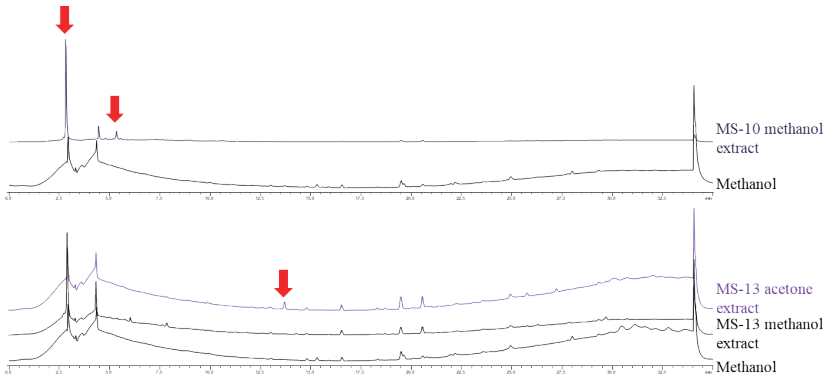


Figure 1. HPLC chromatogram of methanol and acetone extracts of MS-10 and MS-13 samples with distinct peaks indicated by red arrows.

3.2. Untargeted metabolic profiling

3.2.1. LC-MS/MS analysis

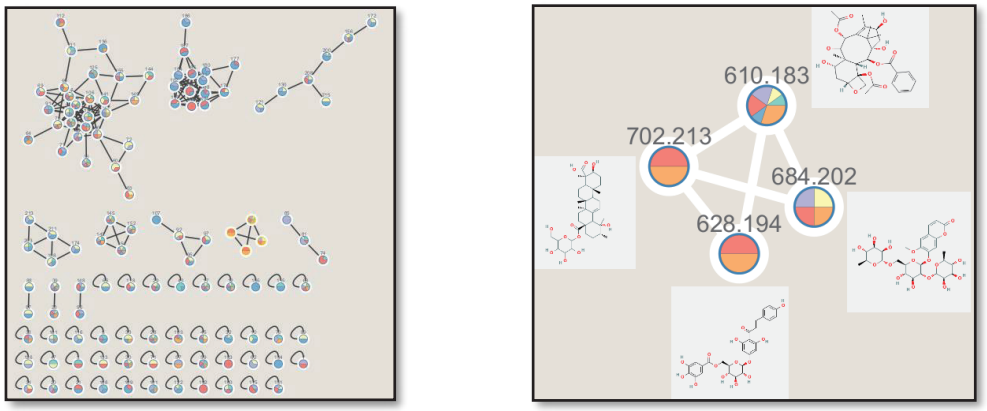
For a more comprehensive exploration of the metabolic profiles of the crude extracts, LC-MS/MS was performed. Database searching of the obtained MS/MS data aided in compound annotation. Indeed, some of the predicted compounds were known for their therapeutic properties, whereas few were FDA approved drugs. For example, Disulfiram and Meglutol were among the predicted compounds that are prescribed for treatment of alcohol addiction and as an antilipemic agent respectively. Table 1 lists the annotated compounds predicted with their bioactivity.

Table 1. List of some compounds present in Antarctic mosses crude extracts and their features identified using LC-MS/MS analysis including their therapeutic properties (reference studies)

S. N	Compound name	RT (min)	Molecular formula	Exact mass	Therapeutic potential
1	Choline alfoscerate	0.669	$C_8H_{20}NO_6P$	257.1023	neuroprotective agent [17,18]
2	Disulfiram	0.624	$C_{10}H_{20}N_2S_4$	296.0501	treatment of alcohol use disorder [19]
3	D-raffinose	0.594	$C_{18}H_{32}O_{16}$	504.1683	anti-adipogenesis, anti-diabetic [20]
4	Meglutol	0.604	$C_6H_{10}O_5$	162.0526	HMG-CoA inhibitor, antilipemic agent [21]
5	methyl palmitate	9.781	$C_{17}H_{34}O_2$	287.2818	anti-inflammatory, anti-fibrotic effect [22]

3.2.2. Molecular networking analysis

Molecular networking is used to analyze unknown compounds by grouping compounds based on their fragmentation spectra similarity. Figure 2 represents the molecular network profile of the moss extracts. Distinct clusters of compounds were observed possibly representing either different classes or family of compounds which requires further explored.



(**a**) (**b**)

Figure 2. Molecular networking of Antarctic mosses based on LC-MS/MS. (**a**) Clusters of networks representing compounds with similar fragmentation spectra; cluster highlighted in yellow; (**b**) indicating predicted compounds sharing similar structures.

3.3. COX-2 inhibition activity

COX-2 activity for each sample treatment was expressed as percentage value with respect to the 100% activity control (Figure 3). COX-2 activity was lowest for MS-13 acetone and MS-10 methanol extracts suggesting presence of COX-2 inhibitors.

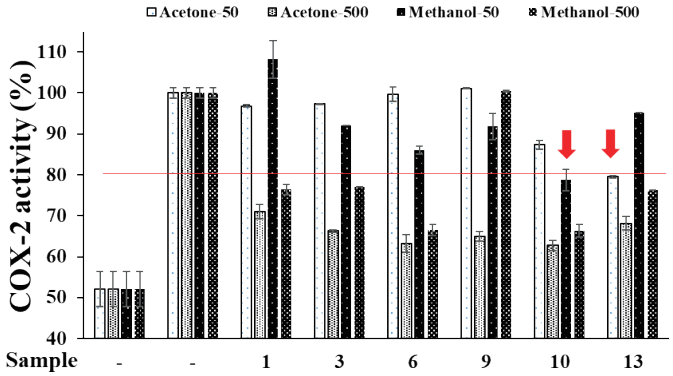


Figure 3. Inhibitory effect of acetone and methanol extracts of different moss samples on COX-2 enzyme activity.

4. Discussion

The growing demand for potent therapeutics due to various health challenges highlights the importance of exploring the least investigated sources like Antarctic mosses. Leveraging the compound databases built on extensive research, knowledge of traditional medicine, and computational tools, it is now much faster and comparatively easier to unravel the chemical space that these resources cover aiding in drug discovery and development [8,23]. This study only covers the preliminary method of screening for bioactive compounds. As seen from the findings in this study, Antarctic mosses hold promising potential to uncover natural treatments for various disease. However, more advanced techniques are required for discovery. Further works will include isolation and deriving structure-activity relationship (SAR) of specific bioactive compounds to elaborate our understanding of mechanism of bioactivity.

5. Conclusions

Traditional knowledge and advancements are the two sides of a coin. This study delves into the significance of Antarctic mosses (the unknown), the methodology of metabolic profiling (the knowledge and advancement), and the potential implications of the findings in the field of medicine (the acknowledged). Finally, it is important to remember that nature has interconnected various species by endowing mutual benefits, enabling them to address each other's challenges; thus, uncovering therapeutic significance and preservation of these vital ecosystems from extinction amid the changing environment ought to go hand in hand towards maintaining a sustainable environment.

Author Contributions: Conceptualization, K.L., R.Y. and T.-J.O.; methodology, K.L., R.Y.; formal analysis, K.L., R.Y. and H.Y.; investigation, K.L., R.Y. and H.Y.; resources, T.-J.O.; writing-original draft preparation, K.L., R.Y., H.Y. and T.-J.O.; writing-review and editing, K.L., R.Y., H.Y. and T.-J.O.; supervision, T.-J.O.; project administration, T.-J.O.; funding acquisition, T.-J.O. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by the project titled "Development of potential antibiotic compounds using polar organism resources (20200610)", funded by the Ministry of Oceans and Fisheries, Korea. In addition, this work was supported by the MISP (Ministry of Science, ICT & Future Planning), Korea, under the National Program for Excellence in SW supervised by the IITP (Institute for Information & communications Technology Promotion) (Grant no. 2018-0-01865).

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Traditional medicine has a long history of contributing to conventional medicine and continues to hold promise. https://www.who.int/news-room/feature-stories/detail/traditional-medicine-has-a-long-history-of-contributing-to-conventional-medicine-and-continues-to-hold-promise (accessed on 10 January 2024).
2. Petrovska, B. B. Historical review of medicinal plants' usage. *Pharmacogn Rev. 6* (11), 1–5 (2012). doi: 10.4103/0973-7847.95849
3. Dias, D. A., Urban, S. and Roessner, U. A Historical Overview of Natural Products in Drug Discovery. *Metabolites 2*(2), 303–336 (2012). doi: 10.3390/metabo2020303
4. Beilinson, H. TRADITIONAL MEDICINE: Using our Past to Advance Our Future. https://yaledistilled.sites.yale.edu/browse-issues/2019-issue/traditional-medicine-using-our-past-advance-our-future (accessed on 10 January 2024)
5. Domingo-Fernández, D. et al. Exploring the known chemical space of the plant kingdom: insights into taxonomic patterns, knowledge gaps, and bioactive regions. *J Cheminform. 15*(1), (2023). doi: 10.1186/s13321-023-00778-w
6. Howes, M. R. et al. Molecules from nature: Reconciling biodiversity conservation and global healthcare imperatives for sustainable use of medicinal plants and fungi. *PLANTS, PEOPLE, PLANET. 2*(5), 463–481 (2020). doi: 10.1002/ppp3.10138
7. Gaudêncio, S. P. et al. Advanced Methods for Natural Products Discovery: Bioactivity Screening, Dereplication, Metabolomics Profiling, Genomic Sequencing, Databases and Informatic Tools, and Structure Elucidation. *Mar Drugs. 21*(5), (2023). doi: 10.3390/md21050308
8. Sadybekov, A. V. and Katritch, V. Computational approaches streamlining drug discovery. *Nature 616*(7958), 673–685 (2023). doi: 10.1038/s41586-023-05905-z
9. Chen, Y., Garcia de Lomana, M., Friedrich, N.-O. and Kirchmair, J. Characterization of the Chemical Space of Known and Readily Obtainable Natural Products. *J Chem Inf Model 58*(8), 1518–1532 (2018). doi: 10.1021/acs.jcim.8b00302
10. Beckonert, O. et al. Metabolic profiling, metabolomic and metabonomic procedures for NMR spectroscopy of urine, plasma, serum and tissue extracts. *Nat Protoc. 2*(11), 2692–2703 (2007). doi: 10.1038/nprot.2007.376
11. Han, W., Ward, J. L., Kong, Y. and Li, X. Editorial: Targeted and untargeted metabolomics for the evaluation of plant metabolites in response to the environment. *Front Plant Sci. 14*, (2023). doi: 10.1038/nprot.2007.376
12. Kontou, E. E. et al. UmetaFlow: an untargeted metabolomics workflow for high-throughput data processing and analysis. *J Cheminform. 15*(1), 52 (2023). doi: 10.1038/nprot.2007.376
13. Gutt, J. et al. Antarctic ecosystems in transition – life between stresses and opportunities. *Biological Reviews. 96*(3), 798–821 (2021). doi: 10.1038/nprot.2007.376
14. Turini, M. E. and DuBois, R. N. Cyclooxygenase-2: A Therapeutic Target. *Annu Rev Med. 53*(1), 35–57 (2002). doi: 10.1146/annurev.med.53.082901.103952
15. Bashir, K. et al. Tandem high resolution mass spectrometry based phytochemical composition of Sauromatum guttatum tubers and its enzyme inhibitory potential with molecular docking. *J Chromatogr A. 1672*, (2022). doi: 10.1016/j.chroma.2022.463055
16. Morehouse, N. J. et al. Annotation of natural product compound families using molecular networking topology and structural similarity fingerprinting. *Nat Commun. 14*(1), 308 (2023). doi: 10.1038/s41467-022-35734-z
17. Ponomareva, L. P., Timoshkina, N. F., Sarantseva, L. N. and Bulanov, A. A Clinical experience in using cereton in ischemic stroke and dyscirculatory encephalopathy. *Neurology, neuropsychiatry, Psychosomatics 2*, (2010). doi: 10.14412/2074-2711-2010-87
18. Catanesi, M. et al. Neuroprotective potential of choline alfoscerate against β-amyloid injury: Involvement of neurotrophic signals. *Cell Biol Int. 44*(8), 1734–1744 (2020). doi: 10.1002/cbin.11369
19. Johansson, B. A review of the pharmacokinetics and pharmacodynamics of disulfiram and its metabolites. *Acta Psychiatr Scand. 86*(S369), 15–26 (1992). doi: 10.1111/j.1600-0447.1992.tb03310.x
20. Muthukumaran, P., Thiyagarajan, G., Arun Babu, R. and Lakshmi, B. S. Raffinose from Costus speciosus attenuates lipid synthesis through modulation of PPARs/SREBP1c and improves insulin sensitivity through PI3K/AKT. *Chem Biol Interact. 284*, 80–89 (2018). doi: 10.1016/j.cbi.2018.02.011
21. Meglutol. https://go.drugbank.com/drugs/DB04377 (accessed on 10 January 2024).
22. El-Demerdash, E. Anti-inflammatory and antifibrotic effects of methyl palmitate. *Toxicol Appl Pharmacol. 254*(3), 238–244 (2011). doi: 10.1016/j.taap.2011.04.016
23. Han, R., Yoon, H., Kim, G., Lee, H. and Lee, Y. Revolutionizing Medicinal Chemistry: The Application of Artificial Intelligence (AI) in Early Drug Discovery. *Pharmaceuticals 16*(9), 1259 (2023). doi: 10.3390/ph16091259

3rd International Conference of Hyojeong Academy

Laccase mediator systems: Virtual screening for Natural mediators

Jayram Karmacharya[1], Prasansah Shrestha[2] and Tae-Jin Oh[1,2,3]*

[1]Department of Life Science and Biochemical Engineering, Sun Moon University, Asan 31460, Korea.
[2]Genome-based Bio-IT Convergence Institute, Sin Moon University
[3]Bio Bigdata-based Chungnam Smart Clean Research Leader Training Program, Sun Moon University
[3]Department of Pharmaceutical Engineering and Biotechnology, Sun Moon University
*Correspondence: tjoh3782@sunmoon.ac.kr

Abstract: Industries are increasingly turning to green chemistry, with laccase enzymes garnering attention due to their ability to use oxygen to produce water as a by-product while catalyzing a wide range of reactions. Bacterial laccases, though less explored, offer stability at high temperatures and pH levels. However, they require mediator systems to handle complex molecules. Structure-based virtual screening aids in identifying suitable mediators, potentially reducing costs, and accelerating discovery. These techniques rely solely on the target protein three-dimensional structure and do not require knowledge of the unique bioactivity of the protein. As a result, structure-based approaches are theoretically more adaptive to unknown protein and ligand compounds than ligand-based approaches. Here, we predicted that natural mediators like coumaric acid show promise comparable to artificial ones, such as N-hydroxythalimide, in computational assessments, suggesting virtual screening's potential in mediator discovery.

Keywords: Laccase, Natural mediators, Artificial mediators, Affinity score.

1. Introduction

Laccases represent a group of multi-copper oxidases responsible for facilitating the oxidation of various substrates, notably phenolic derivatives [1]. These enzymes catalyze reactions wherein the substrate undergoes mono-electronic oxidation, resulting in the formation of the corresponding radical species. Simultaneously, molecular oxygen is reduced to water during these catalytic processes [2]. In many instances, laccases face challenges in directly oxidizing the target substrate, either due to the substrates' inaccessibility to the enzyme or its high redox potential (>1.5 V) [3]. To address these issues, a mediator, typically a low molecular weight compound, can be employed [4]. Laccase-mediator systems have the capability to oxidize a diverse array of substrates, and this ability has been utilized in various applications, including the degradation of dyes[5], transformation of halogenated pesticides [6], oxidation of polycyclic aromatic hydrocarbons [7], and the degradation of endocrine-disrupting chemicals [8] and lignin [9]. Various synthetic compounds, including ABTS, TEMP, VIOL, and HBT, have been employed as laccase mediators in these biocatalytic processes. Nevertheless, the utility of these compounds is significantly restricted due to their high cost, the toxicity of certain by-products, and the need for a large mediator/substrate molar ratio [10]. Indeed, many of the tested mediators have proven to be ineffective as they undergo complete oxidation and are exhausted from the cycle [11]. Consequently, these synthetic mediators have been used in molar ratios as high as 40 to 1 [12]. There is a suggestion that natural mediators could offer a more efficient, cost-effective, and environmentally friendly alternative.

The current exploration of mediators faces two fundamental challenges. Firstly, understanding how a molecule engages with its target, typically a protein like laccase, is essential [13]. Secondly, it's crucial to determine how the same molecule can effectively interact with laccase, considering that the enzyme's site of action is involved. Despite the extensive use of computational chemistry in biological and medical studies, there is a notable scarcity of such investigations in laccase-mediator systems. This scarcity can be attributed to limitations associated with computational chemistry studies in this context, primarily linked to the heterogeneity of available experimental data. Existing literature reveals variations in reaction conditions, including the mediator/substrate molar ratio, nature of the substrate, and the reaction time. Therefore, this research conducted a computational chemistry investigation of laccase mediator systems to accurately define binding sites and examine how the structures of these

binding sites can be effectively as targets in virtual screening.

2. Materials and Methods

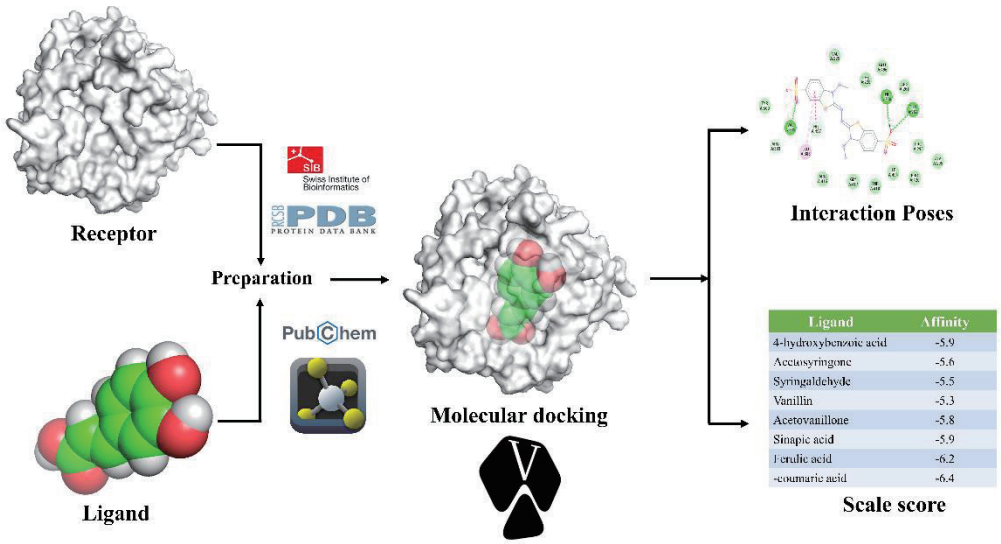
2.1. Data sources

A CotA laccase amino acid sequence of the strain *Bacillus sp.* NP157 was obtained from the National Center for Biotechnology Information (NCBI) genome database (https:www.ncbi.nlm.nih.gov/). The list of natural and chemical mediators was downloaded from PubChem compound database [14].

2.2. Virtual screening of mediators' molecules

The 3D structure prediction of laccase was based on a homology modelling method using UCSF ChimeraX [15]. Furthermore, using AutoDock Tool version 4.1, the ligands and receptor protein were prepared. The processed receptor and ligand structures were docked blindly. Based on the lease energy complex (enzyme and ligand) formation, the best docked complex was selected and was visualized with Biovia Discovery Studio 2021 client 21.1 (BIOVIA, San Diego, CA, USA).

Figure 1. the workflow of virtual screening for mediators.



3. Results

3.1. Enzyme structure prediction and docking with mediator molecules.

Within this software, AlphaFold structure prediction can produce starting protein models, but not as accurate as from experiment. The 3D structure of CotA laccase was predicted based on the highest sequence coverage and local distance difference test (pLDDT) score (data not shown). In total of 14 mediators (6 artificial and 8 natural), the artificial mediotors showed higher binding scores with hgihest value of -7.4 with ABTS and lowest of -6.3 with NAHAN at blind docking approaches. Similarly, with natural mediator the highest binding score is -6.4 with caumari acid and least value is -5.3 with both Vamillin and Acetovanillinone. The binding energy profile of mediator and laccase are depicted in Table 1.

Table 1. Theoretical Binding affinities of mediators

Artificial	ABTS	HOBt	NHPI	VA	NHAN	TEMPO
Binding energy (kcal/mol)	-7.4	-6.3	-6.5	-6.8	-6.3	-7

Natural	HBA	AS	SA	V	AV	S	FA	CA
Binding energy (kcal/mol)	-5.9	-5.6	-5.5	-5.3	-5.3	-5.8	-6.2	-6.4

Note: ABTS; 2,2′-azino-bis(3-ethylbenzothaiazoline-6-sulfonic acid), HOBt; 1-hydroybenzotriazole, NHPI; N-hydroxypthalimide, VA; Violuric acid, NHAN; N-hydroxyacetanilide, TEMPO; 2,2,6,6-Tetramethylpiperidine-1-yl, HBA; 4-hydoxybenzoic acid, AS; Acetosyringone, SA; Syringaldehyde, V; Vanillin, AV; Acetovanillone; S, Sinapic acid, FA; Ferulic aid, CA; Caumaric acid

3.2. Comparison of Natural and Artificial mediators based on binding affinity values

In comparison between artificical and natural mediators that binds to the predicted laccase, only two of the natural mediaotra i.e. Caumaric acid and ferulic acid concides with almost same binding score with N-hydroxybenzotriazole (-6.5 kcal/mol) and N-hydroxyacetanilide (-6.3 kcal/mol) (Fig. 2). While others are not observed in comparison level value of binding energy. Similarly the best dock complexed were observed for interaction posed with the predicted structure (Fig. 3). The best artificial mediator dock complexed showed the conventional hydrogen bond interaction with valine and threonine residues. Whereas in case of natural mediator, it showed conventional hydrogen bond interaction with two asparagine residues.

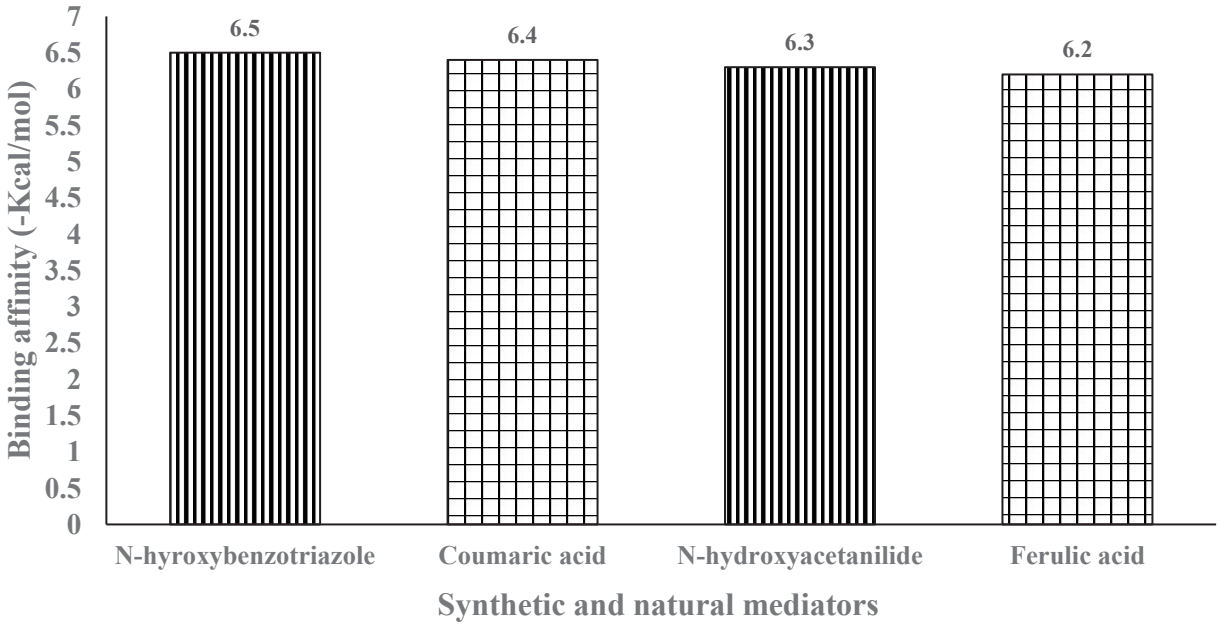


Figure 2. Binding affinity values (kcal/mol) of most comparable artificial and natural mediator

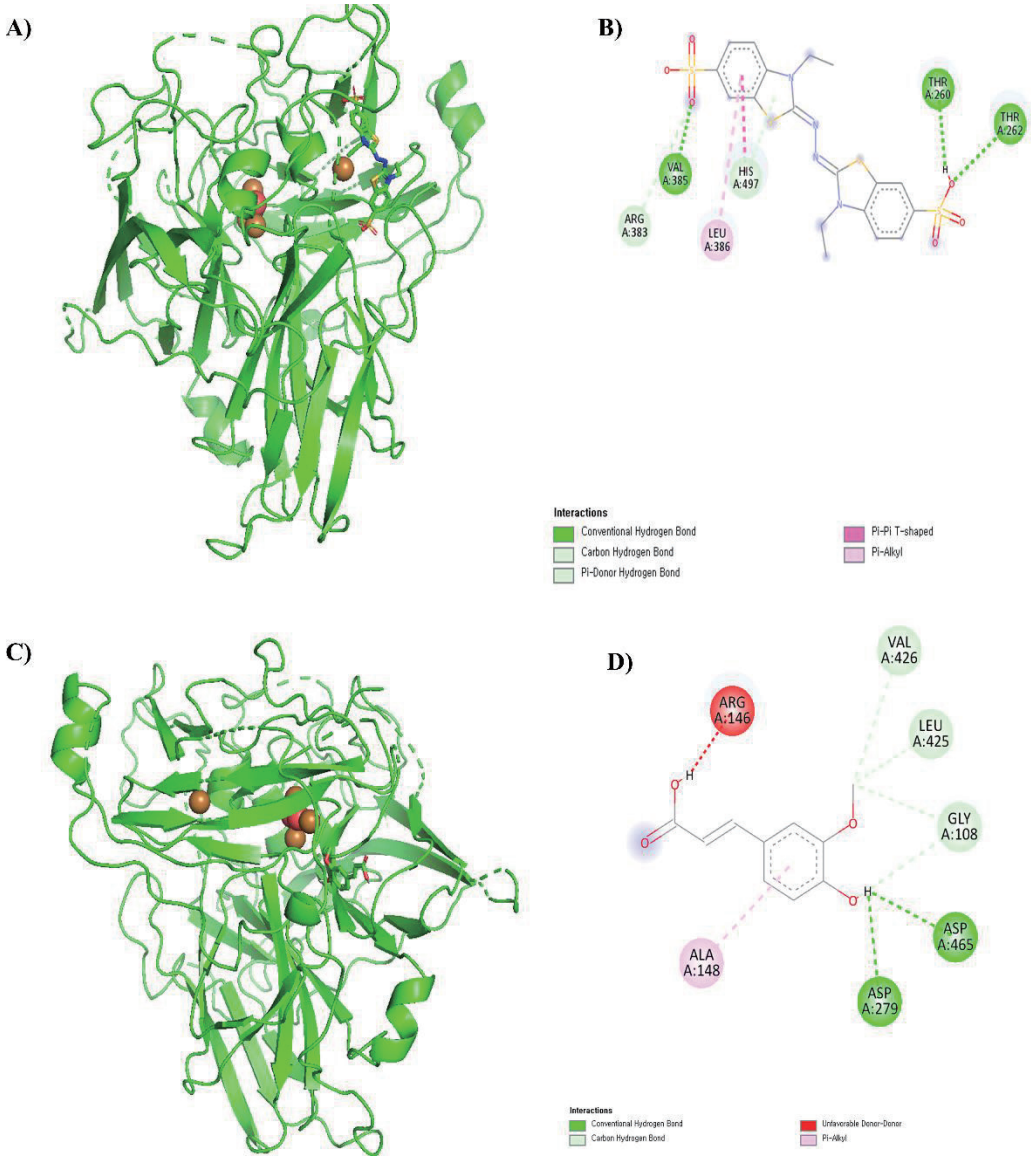


Figure 3. Laccase docked with artificial and natural mediators with interaction pose: A) the docking complexed of laccase with ABTS; B) the interaction poses with did different resides of predicted laccase; C) and D) the docking and interaction posed of laccase with ferulic acid.

4. Discussion

Following Yoshida's discovery of laccase in Japanese lacquer, its vast potential and the onset of a green revolution were unforeseen [16]. Today, it's widely recognized among laccase researchers that natural and/or engineered laccases are central to the revolution. This current challenge lies in producing these enzymes in large quantities and tailoring their biotechnological properties through laboratory evolution combined with rational and semi-rational approaches. Laccase catalyzes two types of reactions: direct oxidation and indirect oxidation. Direct oxidation involves substrate oxidation to the corresponding radical due to direct interaction with the copper cluster [17]. However, in some cases, direct oxidation isn't possible as laccase can only oxidize compounds with an ionization potential below the redox potential of the T1 copper ion [18]. Nevertheless, this limitation can be circumvented using a mediator, a two-step process where the enzyme first oxidizes the mediator which then oxidizes the substrate.

Virtual screening methods are categorized into structure-based virtual screening (SBVS) and ligand-based virtual screening (LBVS). SBVS, which involves docking, requires a 3D structure of the protein target [19], while LBVS techniques utilize libraries of known ligands [20]. Among SBVS techniques, we utilized ChimeraX, which sup-

ports various stages of atomic model construction, including starting model generation, fitting, refinement, validation, and visualization [15]. Although AlphaFold structure prediction in ChimeraX provides initial protein models, their accuracy is not as high as experimental models [21]. These predictions, however, offer a close sequences match with high confidence, suitable as templates for conventional homology modelling [22]. Autodock Vina, frequently used as a reference for docking programs and scoring functions, was employed in our studies [23]. Docking experiments involving mediator-enzyme interactions indicate that artificial mediator molecules closely approach the predicted laccase compared to the natural mediators. Docking possess also suggest proximity to the type T1 catalytic sites, as observed in the laccase-ABTS complex (Fig. 3A and 3B). Additionally, based on the binding affinity comparisons, natural mediators like ferulic acid and coumaric caid approach the predicted laccase similarly to artificial mediators like N-hydroxyacetanilie and N-Hydroxypthalimide. Moreover, mediators exhibit stability in their oxidized and reduced forms, allowing for multiple cycles without degradation, which contributes to their economic and eco-friendly nature, especially when utilizing natural mediators' molecules.

5. Conclusions

In conclusion, this study argued that it is desirable to use some natural mediators such as Coumaric acid and ferulic acid for laccase oxidation reduction reaction in place of artificial mediators. This kind of prediction approach could reduce the screening of many mediators for experimental validation which ultimately reduces the cost. It may be worth more if the docking could be done in target-specific scoring functions for receptors and binding affinities.

Author Contributions: Conceptualization, Jayram. Karmacharya. and Prasansah. Shrestha.; methodology, Jayram. Karmacharya.; software, Jayram. Karmacharya.; validation, Jayram . Karmacharya. and Prasansah. Shrestha. .; formal analysis, Jayram. Karmacharya.; investigation, Jayaram. Karmacharya.; resources, Tae-Jin. Oh.; data curation, Jayram. Karmacharya.; writing—original draft preparation, Jayram. Karmacharya.; writing—review and editing, Tae-Jin. Oh.; visualization, Prasansah. Shrestha.; supervision, Tae-Jin. Oh.; project administration, Tae-Jin. Oh.; funding acquisition, Tae-Jin. Oh. All authors have read and agreed to the published version of the manuscript." Authorship must be limited to those who have contributed substantially to the work reported.

Funding: This research was a part of the project titled " Development of potential antibiotic compounds using polar organisms' resources (20200610, KOPRI Grant PM22030)," funded by the Ministry of Oceans and Fisheries Korea.

Data Availability Statement: Not applicable

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Giardina, P. et al. Laccases: A never-ending story. *Cell. Mol. Life Sci.* 67, 369–385 (2010). https://doi.org/10.1007/s00018-009-0169-1
2. Dwivedi, U.N., Singh, P., Pandey, V.P. and Kumar, A. Structure-function relationship among bacterial, fungal and plant laccases. *J. Mol. Catal. B Enzym.* 68, 117-128 (2011). https://doi.org/10.1016/j.molcatb.2010.11.002
3. Kunamneni, A. et al. Engineering and Applications of fungal laccases for organic synthesis. *Microb. Cell Fact.* 7,32 (2008). https://doi.org/10.1186/1475-2859-7-32
4. Baiocco, P., Barreca, A.M., Fabbrini, M., Galli, C. and Gentili, P. Promoting laccase activity towards non-phenolic substrates: A mechanistic investigation with some laccase-mediator systems. *Org. Biomol. Chem. 1*, 191-197 (2003). https://doi.org/10.1039/b208951c
5. Reyes, P., Pickard, M.A. and Vazquez-Duhalt, R. Hydroxybenzotriazole increases the range of textile dyes decolorized by immobilized laccase. *Biotechnol. Lett. 21*, 875-880 (1999). https://doi.org/10.1023/A:1005502906890
6. Torres-Duarte, C., Roman, R., Tinoco, R. and Vazquez-Duhalt, R. Halogenated pesticide transformation by a laccase-mediator system. *Chemosphere* 77, 687-692 (2009). https://doi.org/10.1016/j.chemosphere.2009.07.039
7. Majcherczyk, A., Johannes, C. and Hüttermann, A. Oxidation of polycyclic aromatic hydrocarbons (PAH) by laccase of Trametes versicolor. *Enzyme Microb. Technol. 22*, 335-341 (1998). https://doi.org/10.1016/S0141-0229(97)00199-3
8. Songulashvili, G., Jimenéz-Tobón, G.A., Jaspers, C. and Penninckx, M.J. Immobilized laccase of Cerrena unicolor for elimination of endocrine disruptor micropollutants. *Fungal Biol. 116*, 883-889 (2012). https://doi.org/10.1016/j.funbio.2012.05.005

9. Hernández Fernaud, J.R. et al. Upgrading of an industrial lignin by using laccase produced by Fusarium proliferatum and different laccase-mediator systems. *Enzyme Microb. Technol*. *38*, 40-48 (2006). https://doi.org/10.1016/j.enzmictec.2005.01.043
10. Camarero, S. et al. p-hydroxycinnamic acids as natural mediators for laccase oxidation of recalcitrant compounds. *Environ. Sci. Technol*. *42*, 6703-6709 (2008). https://doi.org/10.1021/es8008979
11. D'Acunzo, F. and Galli, C. First evidence of catalytic mediation by phenolic compounds in the laccase-induced oxidation of lignin models. *Eur. J. Biochem. 270*, 3634-3640 (2003). https://doi.org/10.1046/j.1432-1033.2003.03752.x
12. Johannes, C. and Majcherczyk, A. Natural mediators in the oxidation of polycyclic aromatic hydrocarbons by laccase mediator systems. *Appl. Environ. Microbiol. 66*, 524-528 (2000). https://doi.org/10.1128/AEM.66.2.524-528.2000
13. Van Regenmortel, M.H.V. A paradigm shift is needed in proteomics: "Structure determines function" should be replaced by "binding determines function." *J. Mol. Recognit*. *15*, 349-351 (2002). https://doi.org/10.1002/jmr.603
14. Kim, S., et al. PubChem substance and compound databases. Nucleic Acids Res. *44*, 1202-1213 (2016). https://doi.org/10.1093/nar/gkv951
15. Meng, E.C., et al. UCSF ChimeraX: Tools for structure building and analysis. *Protein Sci. 32*, e4792 (2023). https://doi.org/10.1002/pro.4792
16. Stanzione, I., Pezzella, C., Giardina, P., Sannia, G. and Piscitelli, A. Beyond natural laccases: extention of their potential applications by protein engineering. *Appl. Microbiol. Biotechnol*. *104*, 915-924 (2019). https://doi.org/10.1007/s00253-019-10147-z
17. Matera, I. et al. Crystal structure of the blue multicopper oxidase from the white-rot fungus Trametes trogii complexed with p-toluate. *Inorganica Chim. Acta*. *361*, 4129-4137 (2008). https://doi.org/10.1016/j.ica.2008.03.091
18. Morozova, O.V., Shumakovich G.P, Shleev S.V. and Yaropolov Y.I. Laccase-mediator systems and their applications: A review. *Appl. Biochem. Microbiol*. *43*, 523-535 (2007). https://doi.org/10.1134/S0003683807050055
19. Stahura, F. and Bajorath, J. New Methodologies for Ligand-Based Virtual Screening. *Curr. Pharm. Des. 11*, 1189-1202 (2005). https://doi.org/10.2174/1381612053507549
20. Ripphausen, P., Nisius, B. and Bajorath, J. State-of-the-art in ligand-based virtual screening. *Drug Discov. Today. 16*, 372-376 (2011). https://doi.org/10.1016/j.drudis.2011.02.011
21. Terwilliger, T.C. et al. AlphaFold predictions are valuable hypothesis, and accelerate but do not replace experimentatl structural determination. *Nat. Methods*. *21*, 110-116 (2023). https://doi.org/10.1038/s41592-023-02087-4
22. Webb, B. and Sali, A. Comparative protein structure modeling using MODELLER. *Curr. Protoc. Bioinforma. 54*, 5.6.1-5.6.37 (2016). https://doi.org/10.1002/cpbi.3
23. Eberhardt, J., Santos-Martins, D., Tillack, A.F. and Forli, S. AutoDock Vina 1.2.0. New Docking Methods, Expanded Force Field, and Python Bindings. *J. Chem. Inf. Model*. *61*, 3891-3898 (2021). https://doi.org/10.1021/acs.jcim.1c00203

Identification of activity and structural review of CYP106A family using cortisol

Kihwa Kim [1,2] and Tae-Jin Oh [1,2,3*]

[1] Department of Life Science and Biochemical Engineering, SunMoon University, Asan 31460, Korea
[2] Genome-Based BioIT Convergence Institute, Sun Moon University
[3] Department of Pharmaceutical Engineering and Biotechnology, SunMoon University
*Correspondence: tjoh3782@sunmoon.ac.kr

Abstract: Enzymes are heme-bound forms, act by receiving electrons from the electron transport system, and mainly exhibit hydroxylation activity. The CYP106A family has hydroxylation activity using steroids and terpenoids as substrates. Corticosteroids include cortisol, which is one of the representative compounds with powerful anti-inflammatory activity. CYP106A1 showed a small but effective activity with cortisol at 19%, and BaCYP106A6, which has high sequence similarity to CYP106A1, also showed activity of less than 20%. However, no activity was shown against CYP106A4 and CYP106A5. As a result, differences in specific residues were confirmed by comparing active sites through homology modeling, which can contribute to protein engineering research by providing insight into the active site of each enzyme.

Keywords: CYP106A, cortisol, homology modeling.

1. Introduction

The Cytochrome P450 enzymes (CYPs) have existed in all kingdoms of life, including humans, plants, and bacteria. These are heme-binding proteins belonging to monooxygenase, and catalyze an oxidation-reduction reaction with drugs, steroids, xenobiotics, and endogenous compounds. Because CYPs metabolize compounds extensively, their activity plays an important role in the biosynthesis of organisms [1]. The heme group of the CYP contains iron ions and exhibits specific activity by receiving electrons from an electron transfer system.

Bacterial CYPs are usually labeled with a three-digit number and show different properties for each family. Among them, steroid hydroxylase enzymes rarely found in bacteria belong to the CYP 106A family, CYP109 family, and CYP 110 family, etc. In particular, the CYP106A family has been studied for CYP106A1 from *Bacillus* megaterium [2], CYP106A2 from *B*. megaterium [3], BaCYP106A2 from *B*. sp. [4], and BaCYP106A6 from *B*. sp. [5], and their steroid hydroxylation activities and protein structures have been identified.

Natural steroids are produced in the adrenal cortex and act primarily as hormones in body metabolism. Steroid hormones include corticosteroids, which have excellent anti-inflammatory effects, and sex hormones that affect sexual maturation. Among them, corticosteroids are compounds with strong anti-inflammatory activity, and representative examples include corticosterone and cortisol. In addition, corticosteroid derivatives such as dexamethasone and prednisolone are used for various pharmacological purposes [6].

To analyze reaction types and predict functional preferences, protein sequence similarity must be considered, and the tertiary structure of enzymes helps scientists to understand this. The active site in the enzyme structure shows how to bind between enzyme and ligand, which is why meaningful to know the protein structure [7]. Additionally, the conserved regions, such as ligand binding motifs, are a key part of functional family classification because they have been inherited from ancestors.

In this study, the new CYP106A family members CYP106A4 and CYP106A5 from *Paenibacillus* sp. were included, their sequence similarity and steroid activity were compared, and structural differences in their active sites were identified. In conclusion, by performing homology modeling on CYPs without structures and comparing the active site with CYPs whose structures have been determined, exploring key residues can provide insight into protein engineering research.

2. Materials and Methods

2.1. Phylogenetic tree and motif analysis through multiple sequence analysis

Among CYPs, 39 enzymes with steroid hydroxylation activity were collected, subjected to multiple sequence analysis, and a phylogenetic tree was drawn to view the evolutionary classification. Sequences were aligned using Cluster W, and a phylogenetic tree was created using the Neighbor-Joining method [8] in the MEGA X [9] program. The WebLogo program (https://weblogo.berkeley.edu/logo.cgi) was used to align sequences to specify motifs.

2.2. In vitro assay and HPLC analysis using cortisol

Cloning, spectroscopic analysis, and HPLC system were performed as described in the previous paper [4]. The in vitro assay was performed in 50 mM potassium buffer applying 10 μM of purified protein, 25 μg of FDX, 0.1 U of FDR, 1 mM of NADPH and the NADPH circulatory system. The substrate, cortisol, was dissolved in DMSO solvent and used at a concentration of 100 μM. The reaction was performed at 30 degrees for 2 hours, and extracted with ethyl acetate solvent to prepare HPLC samples.

2.3. Homology modeling and active site residue comparison for CYP106A4 and CYP106A5

CYP106A4 and CYP106A5 are enzymes whose structures have not been determined. Therefore, the structure was built using homology modeling using the Swiss model program (https://swissmodel.expasy.org/). At this time, the structures of CYP106A1 (PDB ID: 7q9e) and CYP106A2 (PDB ID: 5iki) were used as templates for CYP106A4 and CYP106A5, respectively, according to their most similar amino acid sequences. The shape and overlap of protein structures were confirmed with the PyMOL program [10].

3. Results

3.1. Phylogenetic tree and motif analysis through multiple sequence analysis

Multiple sequence analysis was used to classify 39 steroid hydroxylases and were presented in a phylogenetic tree. The CYP106 family shares one branch with the CYP109 family, meaning it is most similar in sequence. Additionally, the motif was identified and each part was marked in figure 1. In particular, the part of Substrate recognition sites (SRS) 4 related to substrate interaction was confirmed to be quite conserved.

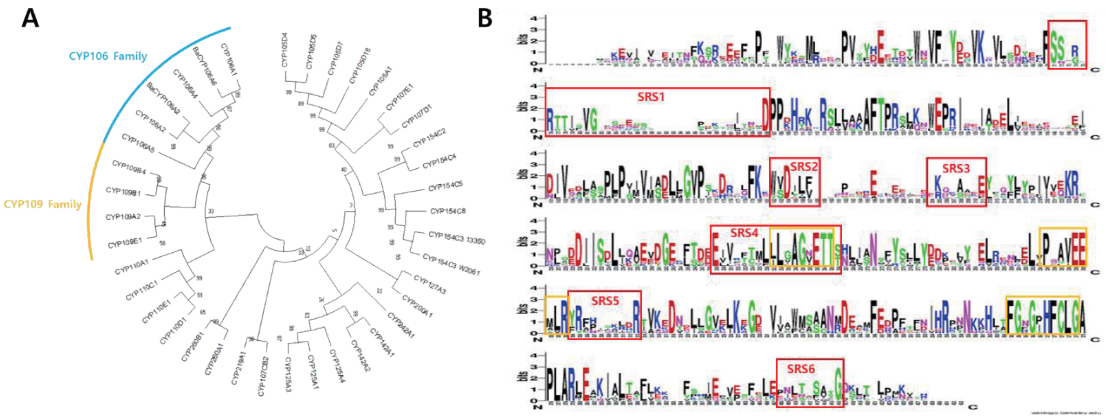


Figure 1. Phylogenetic tree and multiple sequence alignment of steroid hydroxylase. (**A**) The phylogenetic tree is arranged in a circle, and the CYP106 family used in the study is indicated in blue. The most similar CYP109 family in sequence is marked in yellow; (**B**) Multiple sequence alignment was performed into the CYP106 family and CYP109 family, and each motif was marked with a red and yellow box. The red box represents SRS 1-6, and the yellow box is the most conserved CYP unique motif.

3.2. In vitro assay and HPLC analysis using cortisol

The CYP106 family showed a CYP-specific spectroscopic pattern with a peak at 450 nm, and an in vitro assay was performed for substrate specificity with cortisol (Fig 2A). Previous studies have confirmed that CYP106A1, CYP106A2, and BaCYP106A6 react with cortisol and convert it at a low conversion rate. However, CYP106A4 and CYP106A5, which were newly studied in this study, did not convert products from cortisol (Fig 2B).

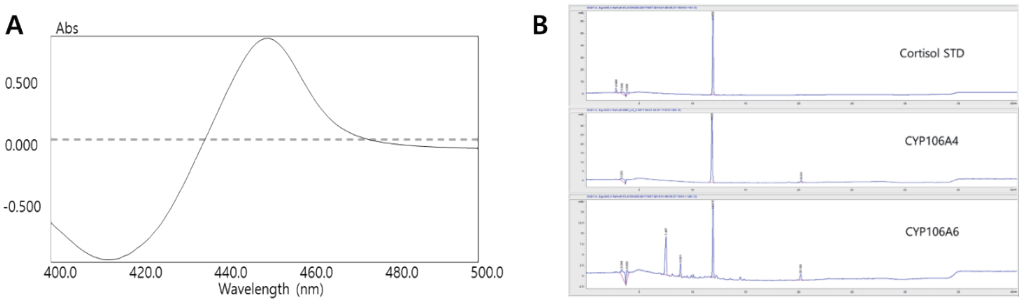


Figure 2. Spectroscopic and HPLC analysis results to confirm CYP characteristics. (**A**) Spectroscopic analysis results using UV-vis.; (**B**) HPLC analysis results obtained by in vitro reaction for 2 hours with cortisol as a substrate for CYP106A4 and CYP106A6.

3.3. Homology modeling and active site residue comparison

CYP106A4 and CYP106A5 are structures obtained through homology modeling, and the active site residues were compared with a model whose structure was already determined. Notably, CYP106A2 had steroid catalytic activity, whereas CYP106A5 was inactive. By overlapping the modeled CYP106A5 with CYP106A2 (PDB ID: 5iki) used as a template, key residues predicted to be involved in substrate binding activity were identified. Residues L239 and L294 in CYP106A2 are comprised of residues F247 and M302 in CYP106A5 (Fig 3A). Therefore, compared to CYP106A2, each residue of CYP106A5 is expected to affect activity by reducing the cavity of the substrate binding active site. As a result of overlapping the CYP106A family centered on the L294 residue of CYP106A2, the determined structures of CYP106A1 (PDB ID: 7q9e), CYP106A2, and CYP106A6 (PDB ID: 8hg9) are composed of R, L, and R residues, respectively, and the modeled CYP106A4 and CYP106A5 are composed of R and M residues, respectively (Fig 3B).

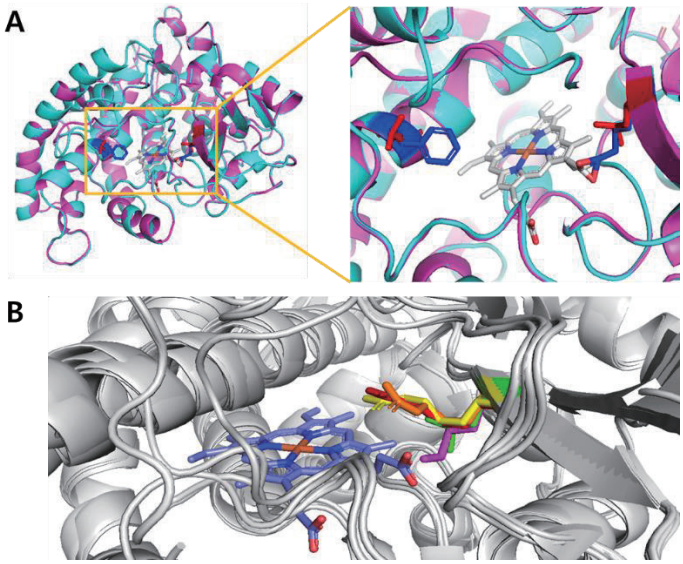


Figure 3. Structural review of the active site of CYP106A family enzymes. (**A**) Superposition results of CYP106A2 (PDB ID: 5iki, pink) and CYP106A5 (modeled structure, cyan). When the active site is enlarged, key residues that show differences between the two enzymes are indicated in red and blue, respectively; (**B**) Overlapping results of five CYP106A family enzymes. The R residue of CYP106A1 is shown in red, the L residue of CYP106A2 is shown in green, the R residue of CYP106A4 is shown in orange, the M residue of CYP106A5 is shown in pink, and the R residue of CYP106A6 is shown in yellow.

4. Discussion

The L residue of CYP106A2 secured the largest space in the active site, and the R residues of CYP106A1 and CYP106A6 showed similar shapes. As reported in previous studies of BaCYP106A6, the R residue is larger than

the L residue, which may hinder substrate binding [5]. Therefore, if this R residue is mutated to a smaller residue, it is expected to increase the binding affinity to the steroid substrate.

The direction of the side chain of the modeled R residue of CYP106A4 is slightly biased, and it is considered necessary to convert this to a smaller residue to check the substrate binding ability of cortisol. The M residue of CYP106A5 was found in only one member of the CYP106A family. This residue is also planned to be studied as a key residue for substrate binding. Additionally, CYP106A4 and CYP106A5 are hypothetical structures created through homology modeling, so in-depth model analysis is required through additional docking and activity assays.

Acknowledgement

This work was supported by the MISP (Ministry of Science, ICT & Future Planning), Korea, under the National Program for Excellence in SW supervised by the IITP (Institute for Information & communications Technology Promotion) (Grant no. 2018-0-01865).

References

1. Jung, S. T., Lauchli, R. and Arnold, F. H. Cytochrome P450: taming a wild type enzyme. *Current opinion in biotechnology* 22(6), 809-817 (2011). doi: 10.1016/j.copbio.2011.02.008.
2. Lee, G. Y., Kim, D. H., Kim, D., Ahn, T. and Yun, C. H. Functional characterization of steroid hydroxylase CYP106A1 derived from Bacillus megaterium. *Archives of pharmacal research 38*, 98-107 (2015).
3. Schmitz, D., Janocha, S., Kiss, F. M. and Bernhardt, R. CYP106A2—a versatile biocatalyst with high potential for biotechnological production of selectively hydroxylated steroid and terpenoid compounds. *Biochimica et Biophysica Acta (BBA)-Proteins and Proteomics, 1866*(1), 11-22 (2018).
4. Kim, K. H. et al. Crystal structure and functional characterization of a cytochrome P450 (BaCYP106A2) from Bacillus sp. PAMC 23377. *Journal of Microbiology and Biotechnology,* 27(8), 1472-1482 (2017).
5. Kim, K. W. Crystal Structure and Biochemical Analysis of a Cytochrome P450 Steroid Hydroxylase (Ba CYP106A6) from Bacillus Species. *Journal of Microbiology and Biotechnology 33*(3), 387-397 (2023).
6. Card T, West J, Hubbard R. and Logan R. F. Hip fractures in patients with inflammatory bowel disease and their relationship to corticosteroid use: a population based cohort study. *Gu.t 53*(2), 251-5 (2004). doi: 10.1136/gut.2003.026799.
7. Jacobson, M. P., Kalyanaraman, C., Zhao, S. and Tian, B. Leveraging structure for enzyme function prediction: methods, opportunities, and challenges. *Trends in biochemical sciences 39*(8), 363-371 (2014). doi: 10.1016/j.tibs.2014.05.006.
8. Saitou N. and Nei M. The neighbor-joining method: A new method for reconstructing phylogenetic trees. *Molecular Biology and Evolution 4*, 406-425 (1987).
9. Kumar, S., Stecher, G., Li, M., Knyaz, C. and Tamura, K. MEGA X: Molecular Evolutionary Genetics Analysis across computing platforms. *Molecular Biology and Evolution 35*, 1547-1549 (2018).
10. The PyMOL Molecular Graphics System, Version 2.0 Schrödinger, LLC.

Proceedings of
THE 3rd INTERNATIONAL CONFERENCE OF
HYOJEONG ACADEMY 2024

Session 3

Technologies

www.lchja.org

High current operation high speed balancing switch design

Hikasa Akio, WanHae Jeon, Vu Than Hai and Innyeal Oh*

Dept. of advanced automotive engineering, Sun Moon University, Asan 31460, Korea
*Correspondence: innyealoh@sunmoon.ac.kr

Abstract: Effectively managing an electric vehicle battery comprised of over 7,000 battery cells is important. Battery management is handled by the BMS (Battery Management System), and the balancing function ensures that all battery cells have the same voltage when charging and discharging. In this paper, we designed a balancing switch to perform the balancing function by selecting the problematic battery cells. The balancing switch should operate with high current characteristics and rapid response features to ensure that the battery becomes safe even in the presence of issues. To accommodate this, the balancing switch should be designed with a transistor having a large gate width to accommodate a large amount of current, while performing a fast on/off switching operation. In this paper, it was recognized that PMOS operation is more important than NMOS when considering the characteristics of PMOS and NMOS that make up the switch, and it was designed with an optimal gate width of 300 um based on the characteristics of resistance (Rds) and capacitance (Cgs) according to the width to secure the balancing switch operation that accommodates 30 mA high current in PMOS and 70 mA in NMOS. Finally, the balancing switch was made to be a switch that supports a high-speed on/off operation of 60 psec while accommodating a high total current of 100 mA. Accordingly, the balancing switch supports a high-current balancing current and supports a safe BMS balancing operation by performing a high-speed on/off operation.

Keywords: Electric vehicle, Battery, Balancing function, High current, Nmos, Pmos

1. Introduction

Lately Global warming cause to emission of carbon dioxide is serious. But Electric vehicle do not worry about CO2 emissions because they operate on a battery basis. Instead, they run on more than 7,000 batter-ies. If even one malfunction occurs between batteries, it can cause a fire accident. Therefore, the battery function of the BMS a constant voltage reference to ensure safe operation. we designed a balancing switch to perform the balancing function by selecting the problematic battery cells. The balancing switch should operate with high current characteristics and rapid response features to ensure that the battery becomes safe even in the presence of issues [1]. To accommodate this, balancing switches must be designed with transistors with large gate widths to accommodate high currents while performing fast on/off switching operations. To ensure balancing switch operation for large currents, an optimal gate width of 300um was designed based on the characteristics of resistance (Rds) and capacitance (Cgs) according to gate width. We also compared this balancing switch design with existing ones by observing the balancing behavior at different temperatures.

2. Analysis of Transistor Operating Characteristics of Balancing Switches

Based on the characteristics of resistance (Rds) and capacitance (Cgs) according to the PMOS/NMOS width, an optimal gate width of 300um was designed, but only about 30 mA could be obtained for Id. This result showed that we need to increase the Width more or increase the Fingers. Total width results determined by equation (1)

$$TW(\text{Total Width}) = FW(\text{Finger Width}) \times F(\text{Finger}) \quad (1)$$

This paper focused on the PMOS characteristics that operate importantly in balancing circuits. In the Figure 1, the target current and actual current changes were plotted. The graph shows that SW 300 was 30mA. In order to analyze the current operating characteristics, Figure 1 shows the ID (Drain-to-Source Current) characteristics according to the PMOS Gate width.

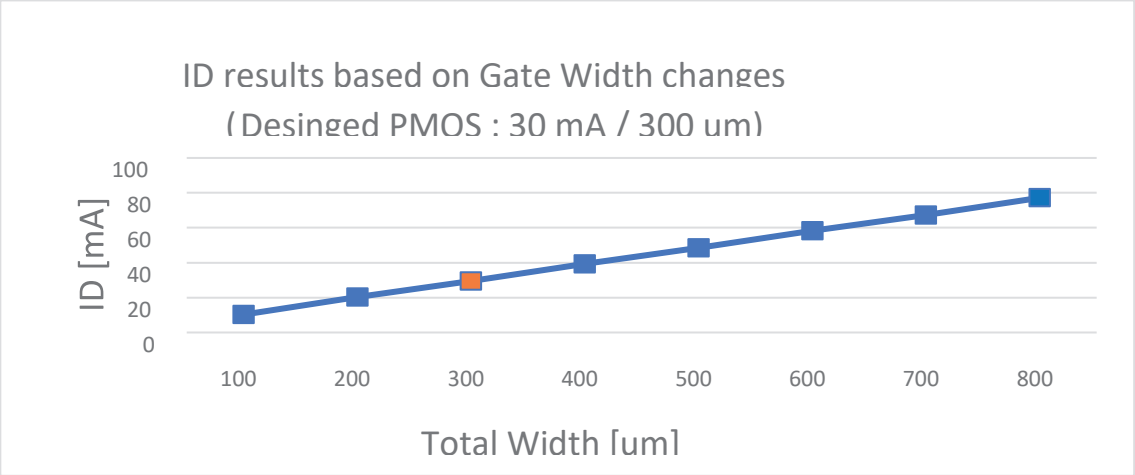


Figure 1. ID results based on Gate Width changes.

The amount of current obtained in the simulation may vary depending on a change in voltage, a change in temperature, and a change in process in an actual experimental environment. The changed amount of current is related to the balancing speed. It is intended to define the balancing operation by considering the current characteristics in real situations. First of all, the current operation according to the voltage change in Figure 2 was examined. As the balancing current operation is determined by the ID, Figure 2 shows the characteristics of the ID current according to the gate-to-source voltage (VGS) that greatly affects the current operation [2]. In the simulation, VGS has a characteristic of 30 mA with a current operation under -4 V condition. This was identified as a phenomenon that can occur if the voltage change in real situation has a maximum amount of change of 107.7%.

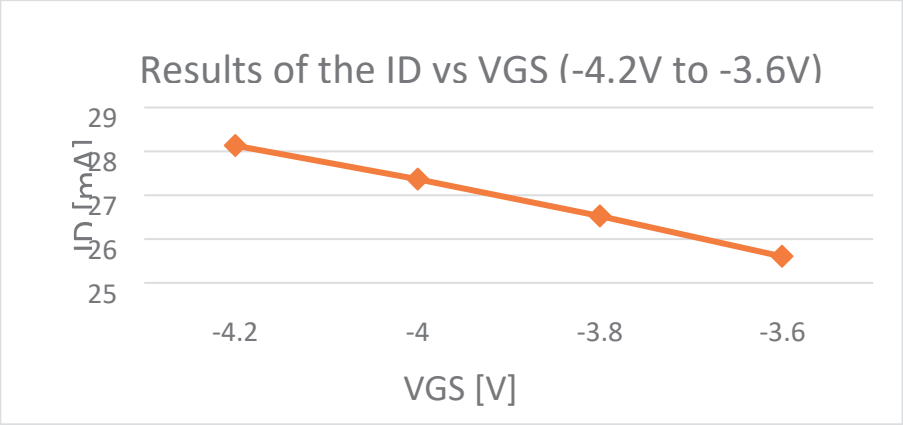


Figure 2. Plot of ID results for voltage (-4.4 [V] to -3.6[V]).

Second, the current characteristics according to the temperature change were examined. The results are shown in Figure 3. If the VGS operates with a voltage change of 1% in an actual experimental environment, the VGS can operate with an error of -3.6 [V] under the condition of -4.2 [V], and the current changes accordingly. Based on Figure 3, it can be seen that the VGS showed a current change of 107.7% at -4.2 [V], and -3.6 [V] showed a current change of 92.3%.

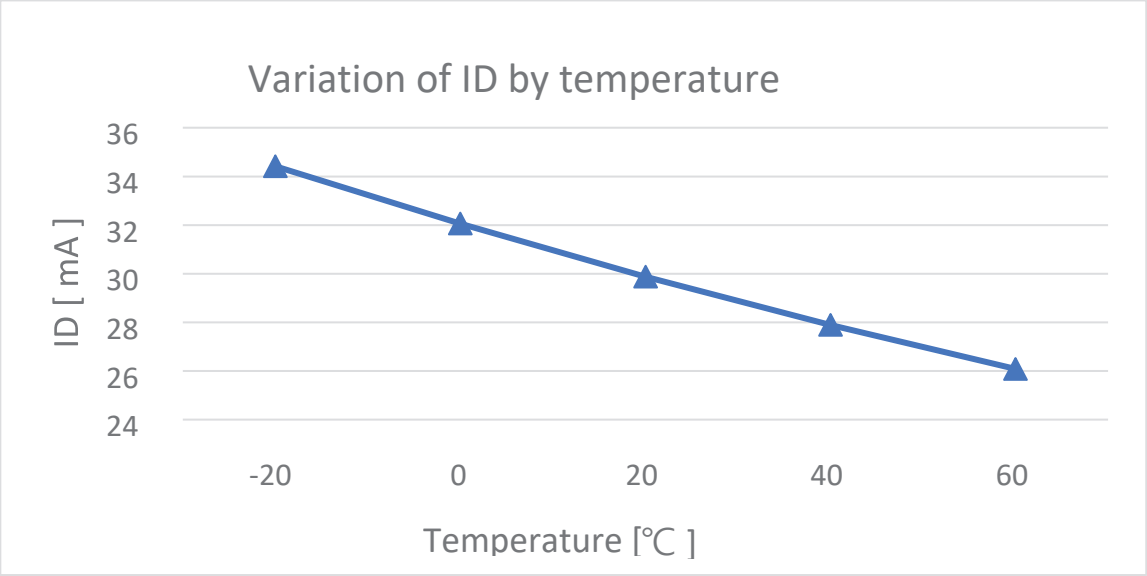


Figure 3. Variation of ID by temperature.

The PMOS and NMOS transistors have the characteristics of ID change according to temperature change along with voltage change. Figure 3 shows the results of ID characteristics according to temperature change. Considering that it can have temperature change characteristics from -20 to 60 degrees in an actual experimental environment, it can be seen that operating in a -20 degree temperature situation based on a 20 degree temperature has a current change of 113% and an 87% current change in a +60 degree situation. The contents of the process change were analyzed at fabricated result. The actual PMOS PCM (Process Control Monitoring) data is shown in Table 1 [3].

Table 1. Fabricated PCM data

CHIP No	PMOS	DOPING ERR	DOPING[%]
Doping charge amount limit	1.08E+02	-	-
Process target doping value	6.00E+01	-	-
1	8.87E+01	2.87E+01	173.5
2	8.88E+01	2.88E+01	173.4
3	8.99E+01	2.99E+01	172.4
4	8.98E+01	2.98E+01	172.5

Table 1 shows that all chips were processed within the doping variation limit value. However, the doping variation value shows a change value of up to 73.5% compared to the doping variation limit. Accordingly, it can be seen that all chips are high-doped up to 50%, and the produced result can be considered to have a larger ID current than the simulation. ID current for process change was analyzed by simulation. First, there are some standards regarding the speed of the switches, so let's get them straight. TT: PMOS Typical (normal doping), FF: PMOS Fast (Highly doping), SS: PMOS Slow (Lowly doping). There is a difference between design results and actual performance. This kind of error is called factory error. The simulation results according to the doping concentration caused by the process error of the designed PMOS are shown in Table 2 of the results of TT: PMOS

Typical (normal doping), FF: PMOS Fast, and SS: PMOS Slow. The operating conditions of Table 2 are the VGS voltage input to the PMOS gate according to the balancing switch operation, set to -4 [V].

Table 2. Characteristics of ID Current Change according to Process Error

VGS= - 4 [V]	ID [mA]	VAR [%]
FF	32.9	110.2
TT	28.9	100
SS	27.4	91.6

As shown in Table 2, it can be seen that if it is operated in FF situation due to process error, it has a current change of 110.2%, and if it is operated in FF situation, it can be seen that it has a current change of 91.6%.

3. Results

In order to analyze the ID current that determines the important characteristics of the varnishing switch, the PMOS operating characteristics were considered. It was found that the current characteristics can vary depending on the change in voltage, temperature, and process. It was found that the analysis bran had a large amount of current change from 92.3% to 107.7%, and it was found that it had a large amount of change in temperature from 87% to 113% with respect to the change in temperature. In addition, it was confirmed that it had a range of 91.6% to 110.2% by the change in the process. It can be seen that the current flows small up to the value of 92.3% + 87% + 91.6% in real situations, or the current up to the value of 107.7% + 113% + 110.2% can have a large amount of change in flow.

4. Conclusions

The designed results differ from the actual values that could be measured by doping based on room temperature, so the chip design must take into account the errors due to the factory, voltage, and current. In this paper, the amount of current change that can be had according to actual environmental changes, focusing on PMOS, was considered. As a result of the analysis, at 300 um, which is the total width condition of the designed PMOS, Balancing current of 30mA can flow as small as 29.1% compared to 30mA due to voltage, temperature, cumulative change of process, etc., so it can have a small current operation up to at least 21.3mA. Conversely, it can be seen that a high current can flow up to 30.9% (39.27mA). Balancing operation should be controlled based on its characteristics.

References

1. Liu, V. T., Lu, H. Y. and Wang, S. K. New Lithium Battery Balancing Circuit Design Using Isolated Converter. In Proceedings of the IEEE Eurasia Conference on IOT, Communication and Engineering, Yunlin, Taiwan 2019.
2. Xiao, P. and Chen, L. Current Situation of Voltage Control in Hunan Power Grid: Overview. In the Proceedings of the IEEE 3rd China International Youth Conference on Electrical Engineering, Wuhan, China 2022.
3. Chai, S. Y. and Choa, S. H. Development of a Real-Time Boron Concentration Monitoring Technique for Plasma Doping Implantation. Crystals 13, 110 (2013).

Evaluation of the Environmental Impact of EVs Driving Performance in Winter

Vu Than Hai, Hikasa Akio, WanHae Jeon and Innyeal Oh*

Dept. of advanced automotive engineering, Sun Moon University, Asan 31460, Korea
*Correspondence: innyealoh@sunmoon.ac.kr

Abstract: Due to climate change issues, automobiles are changing from internal combustion vehicles to electric vehicles. Even though CO2 does not emit at all compared to internal combustion vehicles while driving, drivers have the advantage of costing less than 1/5 of the cost per unit. The improvement in electric vehicles is that winter mileage is significantly reduced to about two-thirds. Electronic devices of electric vehicles consume a lot of current due to a decrease in thermal resistance at low temperatures, and it is also due to the inefficient operation of lithium batteries, which are widely used. In order to analyze the factor that reduces the mileage in winter in electric vehicles, an electric vehicle driving field experiment is conducted to analyze the characteristics of electric vehicle operation. As for the analysis contents, the power consumption characteristics of the electric and electronic device of the electric vehicle through the comparison of the high-speed charging characteristics according to the presence/absence of the electric vehicle starting, the electric vehicle power consumption characteristics of the same time stop operation and driving operation, the change in mileage according to the driving of the city/highway, the change in mileage according to the operating conditions of the heater, and driving performance according to temperature. Based on these results, the general operating characteristics of electric vehicles and differences in characteristics of each vehicle type are presented, the problems and solutions of electric vehicles in winter are reported

Keywords: Electric vehicle, Battery, Charger, Charging speed, Winter

1. Introduction

The world is facing two major problems: energy and the environment that countries need to solve. Meanwhile, traffic plays a very important role in both of these issues, especially now it is also an urgent problem that needs to be solved by all countries in the world. Therefore, vehicles used Using electric energy (electric vehicles), typically electric cars, is being researched and developed vigorously around the world. Electric cars are vehicles powered by electric motors. Instead of using an internal combustion engine with fuel such as gasoline or diesel, electric cars use energy supplied from rechargeable batteries. Electric cars are partly opening up a new direction for overcoming and reduce a large amount of emissions into the environment, causing environmental pollution. But besides that, because we are at the forefront, we still encounter many difficulties that need to be resolved and overcome. Currently, there are still problems. Limitations such as: the infrastructure for charging stations is not completely covered, charging speed is still under concern and research, battery power is still a big problem that needs to be overcome [1,2]. Besides, the weather also affects electric vehicles, especially in countries with winter when the weather is cold [3].

Not only in the future, but now, rich natural resources are increasingly depleted, leading to high oil prices and insignificant people's income. Today, cars run on diesel, gasoline or other fuels are flooding the market, leading to environmental pollution, making the atmosphere worse and worse. The ecosystem changes leading to the greenhouse effect, so the temperature is increasing day by day, making the ice caps in the arctic, Antarctica and other places melted and caused floods and tsunamis, causing the climate to change greatly and causing the world to struggle with energy and environmental issues. Currently, electric cars are very popular. Countries, especially large automobile companies, are interested in research to find new directions for the automobile industry in particular and reduce pollution for the world in general. Besides the denials about the optimal points that electric vehicles are bringing, there are currently also problems and the need to come up with the best solutions for electric vehicles. The limitations of short travel range, few charging stations, time long charging times, long battery life and especially in areas with cold winter climates also greatly affect electric vehicles [4]. In recent years, electric

vehicle companies have overcome these limitations to offer providing consumers with the best and environmentally friendly products.

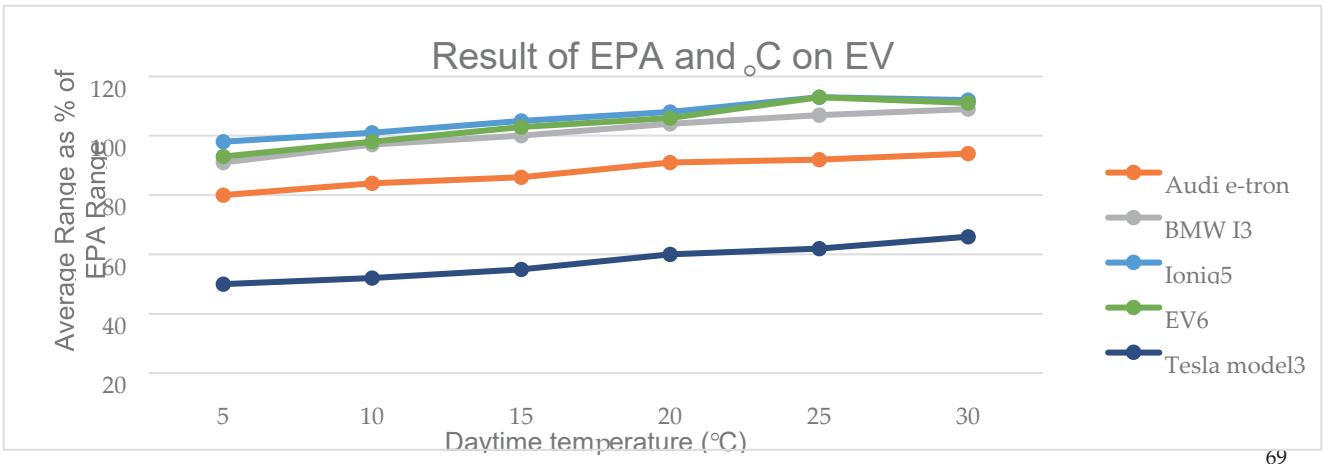
2. Analyzing the Electric Cars performance

Currently, there are many large car companies interested in electric cars. To understand more about electric cars, below is a survey of the indexes of electric car companies that have been greatly improved in recent years.

Table 1. Technical specifications of Ioniq5, EV6, tesla model 3 electric vehicles

Para.	Ioniq5		Tesla model 3		EV6	
	Standard	**Long range**	**Standard**	**Long range**	**Standard**	**Long range**
Weight	1,840kg	2,060kg	1,645kg	1,830kg	1,825kg	2,160kg
Distance driven	384km	458kWh	383km	528km	370km	475km
Bat specifications	58kWh	77.4kWh	50kWh	75kWh	58kWh	77.4kWh
Charging speed	AC 7kW 10 hours	AC 7kW 10 hours	AC 7kW 11 hours	DC 50kW About an hour	AC 3~11kW 9 hours	DC 50~100kW 1 hour
	AC14kW 5 hours	AC14kW 5 hours				
Zero hundred	8.5 sec	5.2 sec	5.6 sec	4.4 sec	3.4 sec	3.4 sec

Through the survey data, we can see that all three types of vehicles have their own features and advantages. The Ioniq5 has electric motors of various capacities. IONIQ 5 is a pure electric vehicle model BEV (Battery Electric Vehicle) with a rechargeable battery system with a capacity of 72.6kWh, using a standard 14 kW AC charger, it only takes 5 hours to fully charge 100%. The car is capable of traveling a maximum of 458km on a single charge under normal operating conditions and can accelerate from 0-100 km/h in 7.4 seconds. Next is the Tesla Model 3, which can accelerate very quickly, from 0-100 km/h in about 4.4 seconds. This makes encroaching on the road, overtaking and operating on the highway more convenient and safer. capable of driving approximately 383-528 km on a full charge, depending on the specific version and specifications. Using a standard DC 50 kW charger with an impressive figure of only 1 hour of charging. Finally, uv6 from 0-100 km/h in about 3.4 seconds is a very impressive number. Capable of driving about 340-475 km on a full charge. These EV performances have great changes in driving performance and battery operation depending on the temperature. It was intended to show the driving results according to the Daytime temperature of the EV, which is widely used in Figure 1. Therefore, the average value of each EV's driving results is expressed in % based on the results stipulated by the Environmental Protection Agency (EPA).



69

Figure 1. Main EV Average Range as % of EPA Range and Daytime Temperature (°C).

As shown in Figure 1, it can be seen that the driving performance of all models varies greatly depending on the temperature. Audi e-tron shows 80% of EPA results at 5 degrees, and 94% of EPA results at 30 degrees. BMW i3 shows 91% of EPA results at 5 degrees and 109% of EPA results at 30 degrees. Ioniq5 shows 98% of EPA results at 5 degrees and 113% of EPA results at 30 degrees. EV6 shows 92% of EPA results at 5 degrees and 113% at 30 degrees. Tesla model3 shows 50% EPA results at 5 degrees and 66% EPA results at 30 degrees. As the temperature drops, the performance of Audi-Etron 14%, BMW i3 18%, Ioniq5 15%, EV6 21%, and Tesla Model3 16% deteriorates.

3. Results

It was found that the temperature greatly affects the battery operation performance and electronic devices of the EV, and the driving performance varies greatly depending on the temperature. These results showed that all models showed a driving change of 14% or more depending on the temperature, and it was also confirmed that the maximum change was 21%. In addition to deteriorating the mileage due to reduced battery efficiency and increased power consumption due to thermal resistance of electric devices when driving electric vehicles in winter, the mileage is further reduced by heating operation. It can be seen that the heater's 3 kWh consumption consumes 15 kWh when driving 350 km for 5 hours, and has an additional 21% battery consumption based on 70 kWh battery capacity only by heating, which further deteriorates the mileage by an additional 21%.

4. Discussion

It can be seen that there is a change in the driving result according to the temperature. This meaning will cause inconvenience to the driver due to the difference in driving results in summer when the temperature is high and winter when the temperature is low. Efforts are required to minimize this amount of change. This amount of change in temperature driving is due to the operating characteristics of the battery and the operating characteristics of the electronic device. In most cases, the change in operating performance of EVs according to temperature change is known as battery characteristics. Currently, the types that are widely used as batteries are NCM battery and LFP battery, and it is necessary to analyze the operating characteristics of the two types of batteries. Moreover, solid state batteries also need to be developed in consideration of the operation according to temperature changes. The operating efficiency of the heater is important as well as battery efficiency. In addition to the high-efficiency design of other electronic devices, the driver's eco-friendly driving habit is also important.

References

1. Williams, L. N. P., Trimble, D. and O'Shaughnessy, S. M. Thermal Management of Lithium-ion Batteries for Electric Vehicles through Immersion Cooling. In Proceedings of the 22nd IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems, Orlando, FL, USA, 2023.
2. Liu, V. T., Lu, H. Y. and Wang, S. K. New Lithium Battery Balancing Circuit Design Using Isolated Con Verter. In Proceedings of the 2019 IEEE Eurasia Conference on IOT, Communication and Engineering, Yunlin, Taiwan, 2019.
3. Xiao, P. and Chen, L. Current Situation of Voltage Control in Hunan Power Grid: an Overview. In Proceedings of the 2022 IEEE 3rd China International Youth Conference on Electrical Engineering, Wuhan, China, 2022.
4. Chai, S. Y., Choa, S. H. Development of a Real-Time Boron Concentration Monitoring Technique for Plasma Doping Implantation. Crystals 13, 2023.

A Proposal for the Development of the PIPM (Prognostic Inspection and Proactive Maintenance) System for SMRs (Small Modular Reactors)

Inho Cho[1], Junhyong Kim[1], Youngsik Pyun[1,*], Auezhan Amanov[2], Seongsik Hwang[3] and Gyeonghoi Koo[3]

[1] DesignMecha Co., Ltd, Asan, Korea
[2] Tampere University, Tampere, Finland
[3] Korea Atomic Energy Research Institute, Daejeon, Korea
*Correspondence: yspyoun@gmail.com

Abstract: The primary maintenance practice in nuclear power plant operation is based on a preventive maintenance policy. The total cost of maintenance over the plant's lifetime is several times higher than the utility cost. With the service period of Small Modular Reactors (SMRs) potentially exceeding 100 years, numerous new technologies in design and manufacturing, including materials, have been introduced to meet safety and economic requirements. A new maintenance strategy, named the Prognostic Inspection Methodology and Proactive Maintenance Methodology, has been introduced, going beyond traditional preventive maintenance. The development of a new maintenance strategy and practice, termed the PIPM (Prognostic Inspection and Proactive Maintenance) System for SMRs, which integrates the Prognostic Inspection Methodology and Proactive Maintenance Methodology, is suggested.

Keywords: Preventive maintenance, Prognostic inspection, Proactive Maintenance, Small Modular Reactor, Nuclear Power Plant, Total Life Time Cost

1. Introduction

"Resilient and robust nuclear power has the potential to play a wider role in the quest towards net zero carbon emissions, while ensuring the highest level of nuclear safety and security" and "it is watershed moment that Net zero carbon for Nuclear power energy to Net Zero" were announced at the wrap-up statement of IAEA looks back at COP28 [1].

Small Modular Reactors (SMRs) could be a promising solution for the demand of the highest level of nuclear safety, security and economic [2]. The future outlook of SMRs markets could be about 145.5 U$ [3]. The goal of SMRs service period could be more than 100 years, so many new technologies in design, manufacturing, and operation have been introduced to satisfy safety and economic requirements.

One of the key elements for SMRs competitiveness is factory production. It is obvious that an assembly plant that does not operate at a sufficient level of volume will fail to achieve economic competitiveness. An important challenge for the factory assembly of SMRs is nuclear regulation. While all safety features of SMRs generally could be addressed within the existing regulatory framework, there are some issues that must be resolved. In particular, current regulatory practices might not be fully compatible with a factory assembly mode, especially if the assembly process is automated. Regulators must adapt their methods of work to test the units to the greatest extent possible at the assembly stage and reduce the potential for rework. Other important regulatory issues include validation of enhanced passive safety systems and multi-modular deployment, the size of the emergency planning zone and the staffing requirements for operation and security. This validation could be obtained with existing procedures, using a risk-informed approach similar to larger nuclear plants. However, SMRs must demonstrate that they can meet safety requirements in ASME Codes & Cases. Regulators and technical support organizations will need time and resources to form opinions on these options and innovations, and this process could lead to delays in SMR licensing [4].

Several SMR alliances or organizations consisting of state-run and private entities in Korea, the EU, the USA, and other countries are developing answers to regulatory issues and leading SMR business development [5]. Several task groups of the Korean international working group in the ASME Standard Committee are organizing to develop the necessary ASME Code and Cases for SMR design, manufacturing, and operation. One of these

groups is focused on maintenance strategy and practice. This study suggests developing a new maintenance strategy and practice for SMRs, named the PIPM (Prognostic Inspection and Proactive Maintenance) System. This strategy and practice should be addressed in the ASME Code and Cases. The effective period of the Code and Cases on the design and manufacturing of SMRs is at most 10 years, but that of operation (maintenance) could be more than 100 years.

2. The concepts and development PIPM Systems

The important regulatory issue in SMRs operation is to develop relevant ASME Code & Cases for maintenance strategy and practice. The current maintenance strategy and practice of Nuclear Power Plant are based on the preventive maintenance that adapts the condition information [6, 7]. The service life of nuclear power plants can exceed 100 years, and the core damage frequency (CDF) should be reduced by 10 to 100 times compared to current nuclear power plants [8]. Therefore, a new maintenance strategy beyond the preventive maintenance based on condition information should be developed.

The goal of this strategy is to prevent any initiation of failure events, such as crack initiation of failure mode under rotary bending fatigue stress, rolling contact fatigue stress, corrosion fatigue stress, and stress corrosion cracking.

2.1. Prognostic inspection methodology

Prognostics and Health Management (PHM) is a system engineering discipline that focuses on assessing the current status and predicting the future condition of a component and/or system of components. PHM is broader than any single field of engineering: it draws from electrical, electronics, mechanical, civil, and chemical engineering, computer and materials science, reliability, test and measurement, artificial intelligence, physics, and economics [9, 10].

This prognostic inspection concept is similar to that of Condition Based Maintenance which is an advanced one of the preventive maintenances [10,11]. But important difference is to measure not crack growth condition, but crack initiation condition in the PIPM system. The concept of prognostic inspection is more close to the concepts of the prognostic inspection in Population Health Maintenance (PHM) studies [12].

Prognostic inspection methodology can detect the condition of components whether it sustains till next or next nth refueling outage or applies proactive maintenance, so it should have measuring, analyzing and deciding function. How to measure that the condition of components is to begin failure mode for an example, to measure the condition of crack initiation, should be developed. New sensor technology integrated with AI which could be available in the future should be considered to develop prognostic inspection methodology., The remaining service life till the beginning of crack initiation should be estimated based on the measuring results by the analyzing function. Whether sustaining the components till next or next nth refueling outage or applying proactive maintenance should be decided by the deciding function,

Typical examples of prognostic inspection methodology are as follows,

1) Rolling bearings,
- Sensing and Monitoring of Vibration, oil debris, Acoustic emission, Energy, Temperature, etc.: usually continuous monitoring [13]
- Measuring and Monitoring of Surface roughness, Micro-cracks, Hardness, Residual stress, Grain size, etc.: usually inspecting during the refueling outage [14]
- Analyzing the remaining service life till the beginning of crack initiation based on the measuring results
- Deciding whether sustaining till next or next nth refueling outage or applying the proactive maintenance

2) Dry canisters [15,16]
- Visual inspection of discontinuities and imperfections on the CISCC (Chloride Induced Stress Corrosion Cracking) susceptible surfaces; usually measuring during the in-service inspection period
- Measuring and Monitoring of Surface roughness, Residual stress, etc.: usually measuring during the in-service inspection period
- Analyzing the remaining service life till the beginning of crack initiation based on the measuring results

- Deciding whether sustaining till next or next nth in-service periods or applying the proactive maintenance

2.2. Proactive maintenance methodology

Proactive maintenance is totally different from preventive and predictive maintenance strategies, as preventive maintenance refers to machine maintenance on planned interims, while predictive maintenance monitors the health status of machine components and alerts when threshold levels are exceeded [17].

Proactive Maintenance encompasses diverse approaches and technologies for the utmost reduction of reactive maintenance in reality. The dominant trait of proactive maintenance is the contrivances of failure origins exploration. Once the failure origins have been identified, the restoring process are carried out and eliminates the adversative failure causes. Proactive maintenance is underscored as a novel strategic maintenance thrust that aims to comprehensively elevate the components' reliability and availability through their system's service life [18].

Proactive maintenance methodology which can be applied to the component during the refueling outage and could restore the fatigue strength of components to the condition of new components should be developed. New and advanced technology that could be available in the future should be considered also for the candidate of the proactive maintenance methodology.

Typical examples of the proactive maintenance methodology are as follows,

1) Rolling bearings [19]
- Exchanging with the new bearings or the remanufactured bearings whose service life is equivalent to new bearing during the refueling outage
- Restoring the bearings using UNSM (Ultrasonic Nanocrystal Surface Modification) technology during the refueling outage.

2) Dry canisters
- Restoring the necessary surface condition by cold splay technology or advanced surface stress improvement technology such as UNSM, Laser Peening, etc. in ASME Code & Case N931 [20]

2.3. PIPM system

The PIPM system is an integration of the prognostic inspection methodology and the proactive maintenance methodology. The proactive maintenance methodology entails the maintenance aspects which should be incorporated at the design stage of a physical asset, whereby all anticipated probable prospective failures are identified and removed, based on the focused historical performance of the asset, with the purpose to prescribe suitable maintenance actions at the right intervals and component parts [21]. So the PIPM system should be developed also from the design phase, especially for the regulator's Safety Evaluation in Design Certification Application (DCA) [22]. For the operation, the detail practice should be addressed into ASME Code and Cases, usually Section XI.

3. Concluding Remarks

The prognostic inspection methodology that can detect the condition before the beginning of the failure mode, such as crack initiation at the components, should be developed. To develop this methodology, new sensor technology integrated with AI, which could be available in the future, should be considered.

The proactive maintenance methodology that can be applied to the component during refueling outage and restore the fatigue strength of components to the condition of new components should be developed. New and advanced technology that could be available in the future should also be considered as a candidate for the proactive maintenance methodology.

The PIPM system integrates the prognostic inspection methodology and the proactive maintenance methodology. It should be addressed in the ASME Code and Cases, usually Section XI. The development of Code & Cases can only be done by the collaboration of several working groups in the ASME standard committee. Experts from

all relevant stakeholders of SMR business should be involved in this work. This work should begin from the design phase of SMRs.

References

1. Nuclear Safety Assurances for Power Plants: Meeting the Demand for Low Carbon Power. https://www.iaea.org/topics/climate-change/the-iaea-and-cop/cop28/highlights (accessed on 13 December 2023).
2. Lokhov, A., Cameron, Ron. and Sozoniuk, V. OECD/NEA Study on the economics and market of small reactors. *Nuclear Engineering and Technology 45*(6), 701-706 (2013).
3. SMR Roadmap technology working group. Canadian SMR Roadmap. In *Technology Working Group Report* (Canadian Nuclear Association, 2018).
4. Small Modular Reactors: Nuclear Energy Market Potential for Near-term Deployment. In *Nuclear Energy Agency No. 7213* (NEA, 2016).
5. Small Modular Reactor Technology. https://smrstart.org (accessed on 01 December 2023).
6. De Jonge, B. and Scarf, P. A review on maintenance optimization. *European Journal of Operational Research 285*(3), 805-824 (2020).
7. Li, Y., Peng, S., Li, Y. and Jiang, W. A review of condition-based maintenance: Its prognostic and operational aspects. *Front. Eng. Manag. 7*, 323-334 (2020).
8. Gaertner, J., Canavan, K. and True, D. Safety and operational benefits of risk-informed initiatives. In *EPRI White Paper* (EPRI, 2008).
9. International Journal of Prognostics and Health Management. https://papers.phmsociety.org/index.php/ijphm/about (accessed on 01 December 2023).
10. Soualhi, A., Lamraoui, M., Elyousfi, B. and Razik, H. PHM SURVEY: Implementation of Prognostic Methods for Monitoring Industrial Systems. *Energies 15*(19), 6909 (2022).
11. Vogl, W., Weiss, G. and Alkan, D. Standards for Prognostics and Health Management (PHM) Techniques within Manufacturing Operations. *Annual Conference of the PHM Society 6*(1), (2014).
12. Kent, P. et al. A conceptual framework for prognostic research, *BMC Medical Research Methodology 20*, 172 (2020).
13. Lee, J. et al. Prognostics and health management design for rotary machinery systems - Reviews, methodology and applications. *Mechanical Systems and Signal Processing 42*, 314–334 (2014).
14. Kim, J., Cho, I. and Pyun, Y. A Prognostic Inspection and Proactive Maintenance System (PIPM) to Bring Snowball Effects on the Transition to the Circular Economy and a Carbon-Neutral Society. *The journal of Hyojeong Academia 2*(1), 12-16 (2023).
15. Code and Case N-860, Inspection Requirements and Evaluation Standards for Spent Nuclear Fuel Storage Section XI Division 1 and Division 2, ASME. https://cstools.asme.org/csconnect/CodeCaseForm.cfm?Action=View&CaseNumber=2544&NoToolbar=yes (accessed on 06 July 2020).
16. Broussard, J. E. Technical Basis Summary for Code Case N-860: Inspection Requirements and Evaluation Standards for Spent Nuclear Fuel Storage and Transportation Containment Systems (PVP2021-64176). In Proceedings of ASME PVP 2021, Virtual, Online (13-15 July 2021).
17. Exner, K., Schnürmacher, C., Adolphy, S. and Stark, R. Proactive maintenance as success factor for use-oriented Product-Service Systems. *Procedia CIRP 64*, 330-335 (2017).
18. Papic, L., Aronov, J. and Pantelic, M. Safety Based Maintenance Concept. *International Journal of Reliability, Quality and Safety Engineering 16*(6), 533–549 (2009).
19. Darisuren, S. et al. Remanufacturing process and improvement in fatigue life of spherical roller bearings. *Journal of KSTLE 30*(6), 350-355 (2014).
20. Kim, J., Cho, I., Pyun, Y. and Amanov, A. Code Case N-931 and UNSM Technology for the Improving Service Life and Safety of Nuclear Power Plant. In Proceedings of the 2nd International Conference of Hyojeong Academy, Asan, Korea (Aug. 31-Sep. 2 2023).
21. Chaïb, R. et al. Failure: a source of progress in maintenance and design, *Physics Procedia 55*, 185-191 (2014).
22. NuScale DCA Safety Evaluation Reports with Open Items. https://www.nrc.gov/docs/ML1919/ML19191A196.html (accessed on 4 December 2019).

Emotion Recognition Technique: A Brief Review

Byung-Gyu Kim

Sookmyung Women's University, Seoul 04310, Korea
Correspondence: bg.kim@sookmyung.ac.kr

Abstract: Recently, the emotion recognition technology has been widely attempted in various fields. To recognize a person's emotional state, algorithms are fundamentally implemented based on biometric signals originating from individuals. In this paper, we aim to comprehensively explore the basic processing steps of emotion recognition, various forms of signals for recognition, and the corresponding recognition techniques. Furthermore, we examine the challenges and issues associated with vision-based technology, particularly in non-contact applications, and discuss research areas that need to be addressed in the future.

Keywords: Emotion recognition, Deep learning, Biometric signals

1. Introduction

Communication skills have been developed based on the senses that play an important role in human interaction. There are five human senses: sight, sound, touch, taste, and smell. There is no doubt that sight is the most important one of the five senses for most people, since up to 80% of all senses are recognized through sight [1].

In recent years, the field of emotion recognition technology has witnessed significant advancements, with applications spanning diverse domains. The core of emotion recognition lies in the implementation of algorithms that decode biometric signals emanating from individuals to discern their emotional states. This paper aims to provide a comprehensive overview of the fundamental processing steps involved in emotion recognition, the various forms of signals utilized for this purpose, and the corresponding recognition techniques.

As we delve into the intricacies of emotion recognition, special emphasis will be placed on non-contact approaches, particularly leveraging vision-based technology [2-5]. Through this exploration, we will scrutinize the inherent challenges and potential issues associated with such methodologies. Additionally, this review will identify and discuss key research areas that demand attention and further investigation in the future.

2. Emotion Recognition Techniques

Emotion is defined as biologically-based psychological states brought on by neurophysiological changes, variously associated with thoughts, feelings, behavioural responses, and a degree of pleasure or displeasure. Emotions are very complex and the physiology of emotion is closely linked to arousal of the nervous system [6]. In psychology and philosophy, emotion typically includes a subjective, conscious experience characterized primarily by psychophysiological expressions, biological reactions, and mental states.

Figure 1 shows the emotion classes [7]. Emotion recognition is a technique that automatically extracts the features on human face to recognize the patterns of expression. In general, it identifies the state of emotions by classifying 6–8 major emotions such as angry, disgust, fear, happy, sad, and surprise.

Besides these eight emotions, there are also many types of research for classifying subtle expression. To reach this goal, it should be able to analyze the facial expression even if it is not a typical expression. Facial Action Coding System (FACS) can be a tool to understand the human face [7].

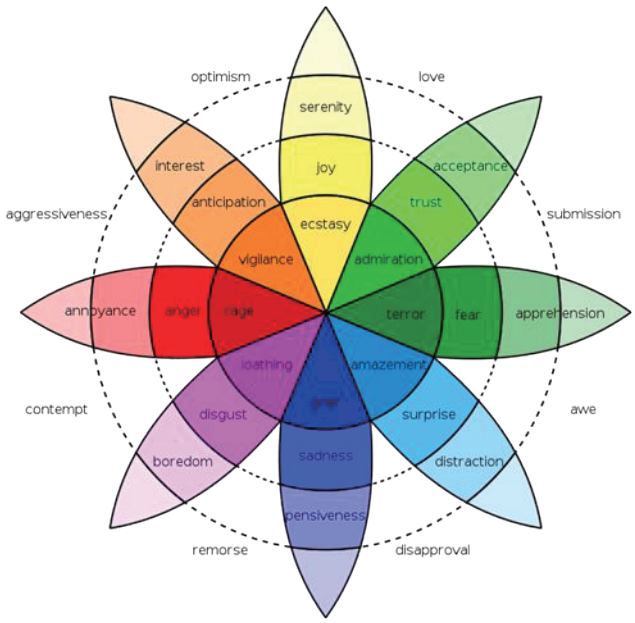


Figure 1. Emotion classes.

From the next sub-section, we will investigate approaches to recognize the human-being's emotion.

2.1. Audio: Human's speech signal

In speech emotion analysis, various methods to analyze vocal behavior as a marker of affect can be designed. The basic assumption is that there is a set of objectively measurable voice parameters that reflect the affective state a person is currently experiencing.

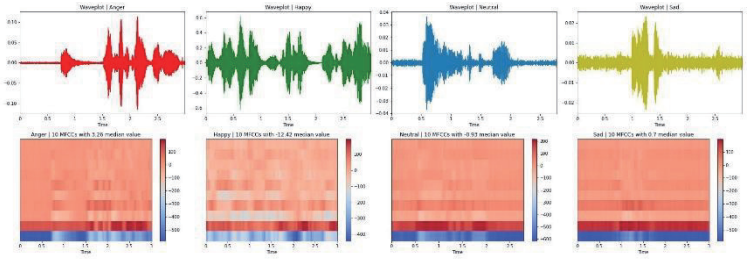


Figure 2. Speech pattern according to emotional states.

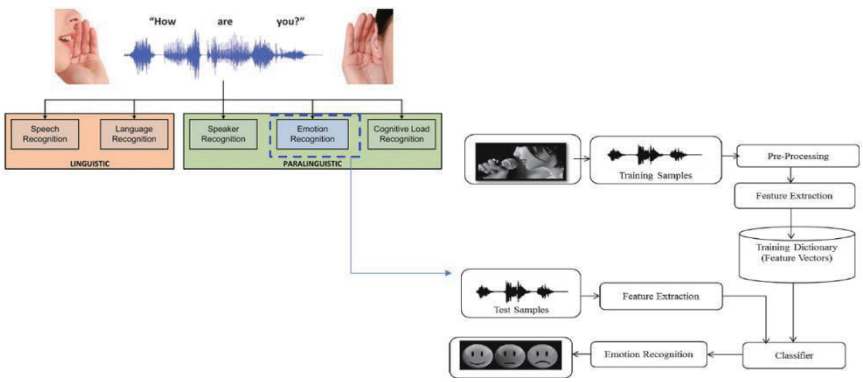


Figure 3. Speech pattern-based emotion classification scheme.

2.2. Visual: Image & Video Signal

In Facial expression (emotion) recognition (FER), there are various methods to analyze facial behavior (pattern) as a marker of affect. The basic assumption is that there is a set of objectively measurable image parameters that reflect the affective state a person is currently experiencing.

Figure 4 shows the vision-based emotion recognition approach. Initially, preprocessing is applied to enhance the quality of the input video. Subsequently, features are detected from the preprocessed video, and the identified features are then recognized using modern deep learning architectures such as CNNs (Convolutional Neural Networks) and LSTMs (Long Short-Term Memory). This process enables the recognition of individual facial expressions.

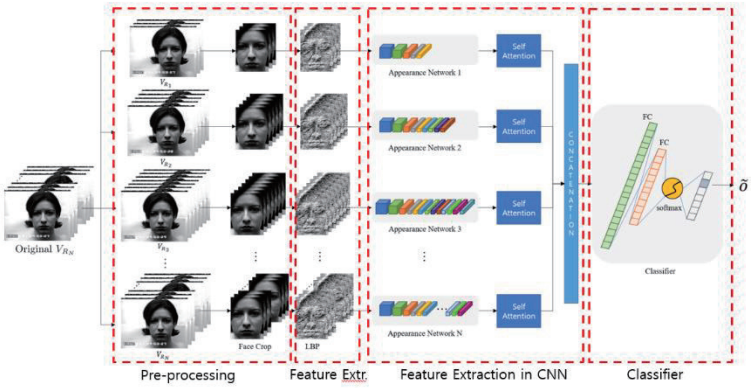


Figure 4. Facial expression-based emotion recognition scheme [2].

2.3. Brain: EEG signals

Based on EEG electrode system in Fig. 5, the captured signal is processed as a state of emotion.

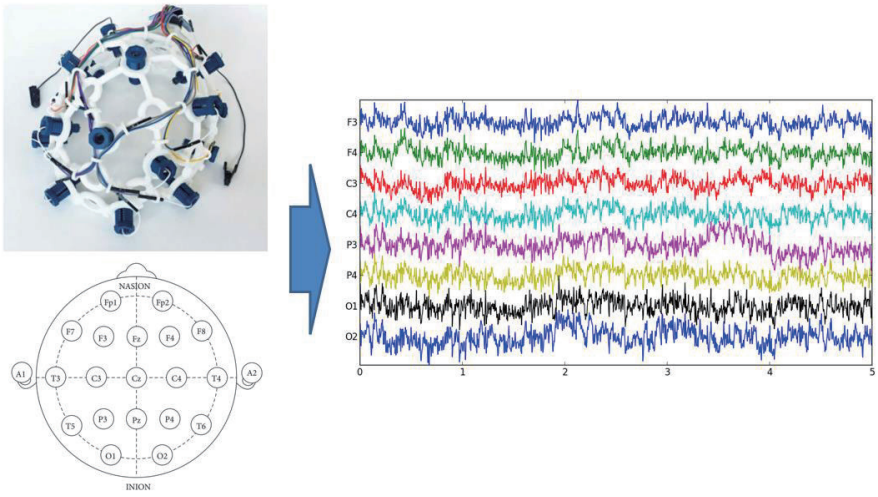


Figure 5. Brain signal pattern for emotion recognition.

EEG signals are highly susceptible to noise, making the role of signal filtering crucial. Subsequently, for time-series data, identification can be particularly challenging. In recent times, a prevalent approach involves transforming the data into image spectrums for improved recognition. Figure 6 illustrates a representative architecture utilizing spectrogram features. The deep learning structure is popular for classifier, too.

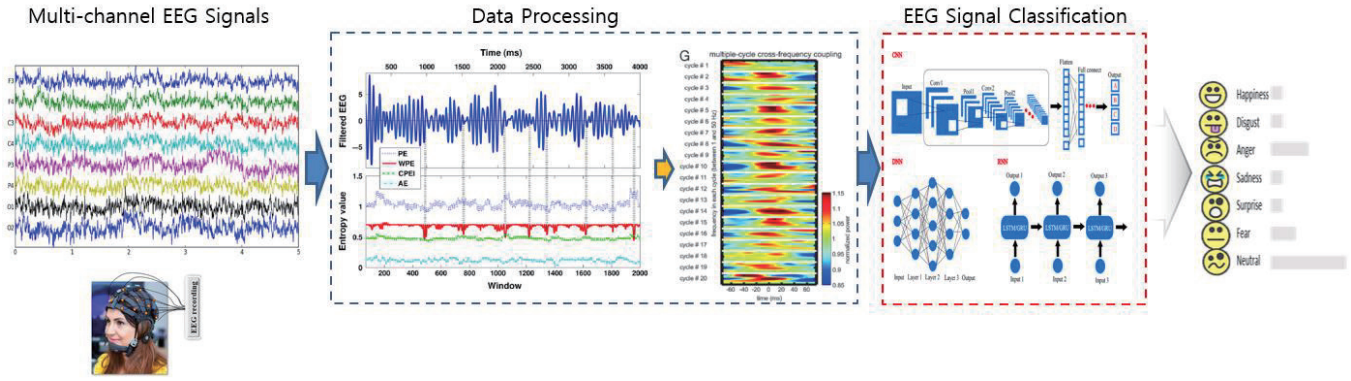


Figure 6. Brain signal-based emotion recognition scheme.

2.4. Written Text: from chatting or dialog system

Various sentences written in chat programs like Twitter also carry the emotions of individuals as shown in Fig. 7. Extracting features from these expressions, a technology has been developed to recognize the emotions of users participating in a chat based on the coherence and correlation of the conversation. For this recognition technology, natural language processing is fundamentally required to extract emotional features through analyzing the contextual relevance and correlation of the conversation.

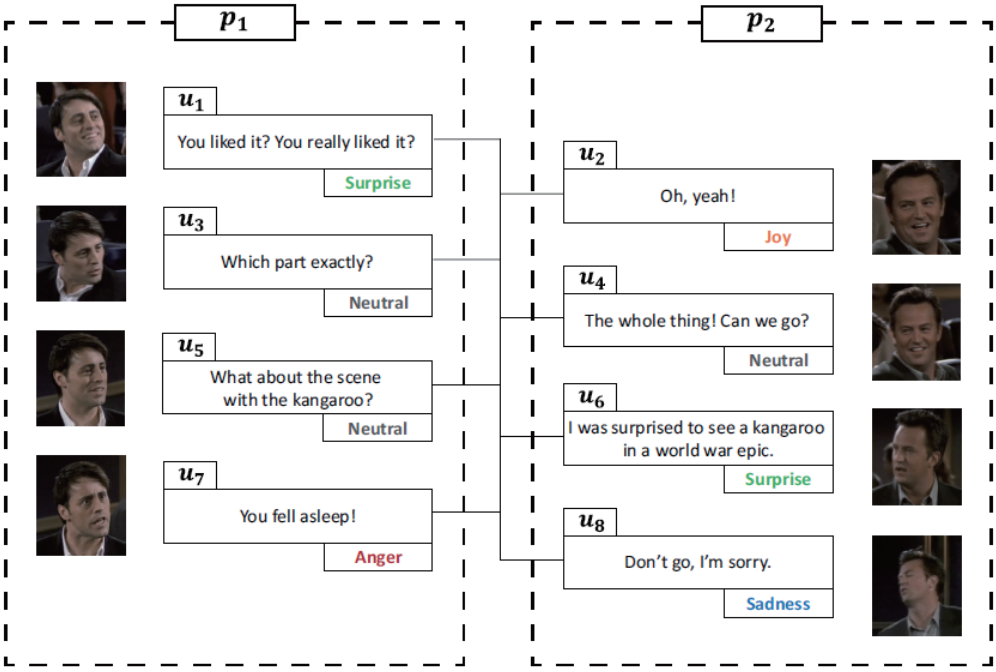


Figure 7. Text-based patterns for emotion recognition.

3. Results Research Trend & Challenge

3.1. Increasement of input data dimension

Currently, video data is typically in 2D, but the dimensions of such data are expanding to 3D and 4D, accompanied by a continuous increase in data volume. To enable real-time processing or services, high-performance computing devices are essential due to the growing complexity of these datasets.

3.2. Multi-modal approach

Rather than relying on a single biometric signal, a viable approach would be to combine validated signals to identify emotions. In such multimodal recognition technology, a crucial aspect arises in determining which data

to prioritize, emphasizing the importance of selecting relevant and meaningful information for accurate emotion identification.".

3.3. Context-aware emotion recognition

It is well-known that human emotions are to some extent influenced by the surrounding environment. In other words, the current user's space, immediate surroundings, as well as the user's body language and gestures, can adequately reflect the current emotional state. Leveraging such information could lead to a more accurate identification of the user's emotional state.

3.4. Challenges on Dataset

1. Racial differences: This is a big challenge even for the most profound AI solutions. For example, in 2015, Google Photo algorithms didn't recognize people with dark skin.
2. Psychological challenges: Psychologists have been studying the connection between facial expressions and emotions since the 1950s. Yet there are still a lot of blindspots.
3. Cultural differences in emotional: In Western cultures, most people express each of the seven basic emotions with a distinct set of facial and body movements. Japanese and Chinese people, however, are usually more restrained, indicating emotions only with distinctive eye activity.
4. Identifying children's emotions (wider ages): There is a shortage of training data for facial expressions of young children and babies. Consequently, the accuracy of emotion recognition for children and infants is lower than expected. Addressing this issue is one of the challenges that need to be overcome in improving the accuracy of recognizing facial expressions and emotions in young children.

4. Conclusion

In this paper, we have examined various biometric signals and diverse approaches for emotion recognition in humans. We delved into the utilization of biometric signals for feature extraction through transformations and explored various technological structures for emotion recognition. Furthermore, we discussed potential improvements in approaching emotion recognition, addressing issues such as dataset dependency in utilizing deep learning, and considerations related to emotional expression variations across different races.

References

1. Rosenblum, L.D. *See What I'm Saying: The Extraordinary Powers of Our Five Senses*, 1st ed. (Norton Company, 2010).
2. Park, S., Kim, B. and Chilamkurti, N. A Robust Facial Expression Recognition Algorithm Based on Multi-Rate Feature Fusion Scheme. *Sensors 21*(6954), 1-26 (2021). https://doi.org/10.3390/s21216954
3. Jeong, D., Kim, B. and Dong, S. Deep Joint Spatiotemporal Network (DJSTN) for Efficient Facial Expression Recognition. *Sensors 2020*(20), 1963 (2020). https://doi.org/10.3390/s20071936
4. Kim, J., Kim, B., ROY, P. and Jeong, D. Efficient Facial Expression Recognition Algorithm Based on Hierarchical Deep Neural Network Structure. *IEEE Access* 7, 41273-41285 (2019). https://doi.org/10.1109/ACCESS.2019.2907327.
5. Kim, C. and Kim, B. Few-shot Learning on Facial Expression Recognition: A Comprehensive Survey. *Journal of Real-Time Image Processing* 20(52), 1-18 (2023). https://doi.org/10.1007/s11554-023-01310-x
6. Jerritta, S., Murugappan, M., Nagarajan, R. and Wan, K. Physiological signals based human emotion recognition: a review. In *2011 IEEE 7th International Colloquium on Signal Processing and Its Applications* (IEEE, 2011).
7. Ekman, P. and Friesen, W. *Facial Action Coding System: A Technique for the Measurement of Facial Movement* (Consulting Psychologists Press, 2020).

Prognostic inspection for proactive maintenance

Junhyong Kim[1], Inho Cho[1], Youngsik Pyun[1,*] and Auezhan Amanov[2]

[1]DesignMecha Co., Ltd, Asan, Korea
[2]Tampere University, Tampere, Finland
*Correspondence: yspyoun@gmail.com

Abstract: Preventive medicine aims to promote health by investigating and researching the distribution of health and health-related risk factors. The desired life time of the SMR (small modular reactor) being developed as a new energy source is more than 100 years. Improving the problems of key components such as SCC (stress corrosion cracking) and corrosion fatigue of the SMR structures and erosion and fretting fatigue of turbine blades improves the service life of the SMR. Also, in bearings, it improves wear and rolling/sliding contact fatigue. It is necessary to develop a proactive maintenance program prior to design to ensure that the SMR can be shut down after operation within its designed lifespan. Like preventive medicine, proactive maintenance programs applied to the SMR must also be inspected in advance to ensure that the characteristics of key components do not deteriorate or exceed predetermined standards. Additionally, it is necessary to develop and standardize technology that restores the characteristics of key components to their designed performance state. In this paper, we look at the precursors of risk factors such as SCC/corrosion fatigue and rolling contact fatigue. And we look at the research results on this impact on the SMR service life and the standards currently applied in ASME section XI, etc.

Keywords: Prognostics and Health Management (PHM), Biomarker, Prognostic Inspection and Proactive Maintenance (PIPM), Small Modular Reactor (SMR)

1. Introduction

Devices and systems used in various industrial fields are damaged for various reasons even when they are optimally designed. Preventive maintenance is the process of periodically replacing parts to prevent this. However, it requires high costs every year and is not excellent at preventing accidents. Recently, as the use of big data and machine learning has increased, Prognostics and Health Management (PHM), a technology for diagnosing and prognosis fault, is being researched and applied [1-4].

Meanwhile, as the Homo Hundred approaches, the health and medical field recognizes the importance of Population Health Management (PHM), and research and development of PHM is steadily progressing. A program where patient data is compiled from various sources of health information technology is referred to as the PHM. Most the PHM applications gather data using a business intelligence platform, enabling healthcare practitioners to create a precise and accurate medical picture of each patient [5]. Chronic diseases are a major force driving the PHM. For example, increasing prevalence of chronic diseases such as diabetes, hypertension, and cancer increases the PHM market growth rate. The PHM requires advanced information technology systems and tools that can collect, store, process, and analyze large amounts of health data, and biomarkers are an important element of the PHM [6]. Biomarkers have been used in clinical practice for personalizing medication or healthcare, as well as for analyzing the safety of pharmaceuticals. These biomarkers are produced either by organs affected by the disease or by the body in response to various diseases. They are utilized to monitor the progression of a disease [7, 8].

Prognostics and Health Management (PHM) in the industrial field also identifies and monitors factors that affect the progression of damage, such as biomarkers. After analyzing the values of these factors for the current state using big data-based data, it is decided whether or not to carry out maintenance. The application of big data-based PHM is increasing in bearings, gears, and shafts in the mechanical field, based on a wide range of failure cases [9]. If the Stress Corrosion Cracking (SCC) and corrosion-fatigue problems of the Small Modular Reactor (SMR), which is being developed as a new energy source, are improved through the PHM, the service life of the SMR will increase. In this study, we would like to introduce Prognostic Inspection and Proactive Maintenance (PIPM) and ideas for applying it to SMR.

2. Prognostic Inspection and Proactive Maintenance (PIPM) Systems

2.1. Different types of maintenance

Reactive Maintenance (RM) only repairs or replaces machine parts when an error occurs and they can no longer function. The advantage of this method is that the cost associated with maintenance personnel and maintaining machine operation is low. However, since the machine or parts are used until they break down, the probability of serious failure increases, and the repair cost also increases [10].

Scheduled Maintenance (SM) is a maintenance method performed at regular time intervals. The goal is to perform maintenance activities even while the machine is operating under normal conditions to minimize the possibility of failure and prevent costly unplanned downtime. On the other hand, the SM method requires performing some costly maintenance interventions even when the equipment is still functioning properly [4].

Condition Based Maintenance (CBM) and Prognostics and Health Management (PHM) both focus on maintaining system reliability and reducing system downtime. However, there are some key differences between the two approaches. CBM is a maintenance strategy that uses sensors and data analytics to monitor the real-time performance of assets or equipment. CBM uses real-time data to identify maintenance needs, making maintenance more efficient and cost-effective rather than performing maintenance on a predetermined schedule or waiting for equipment to fail [11]. PHM, on the other hand, is a technology that enables CBM and has the ability to predict the Remaining Useful Life (RUL) of a system while it is in operation. PHM helps implement CBM, a new maintenance approach that addresses repair or replacement only for actual damage to components. PHM can therefore be viewed as a more advanced approach than CBM, enabling more accurate predictions and improved maintenance decisions [12].

The most common applications of PHM in the mechanical field are bearings, gears, and shafts. As shown in Table 1, PHM is implemented through algorithm analysis by collecting failure modes, characteristics, and common features [9, 13].

Table 1. Summary of PHM of mechanical components

Component	Failure mode	Characteristic	Common feature	Common algorithms used
Bearing	Outer-race, innerrace, roller, cage failures	Raw data does not contain insightful information; low amplitude; high noise	Vibration characteristic frequency, time domain statistical characteristics, metallic debris shape, size, quantity, sharp pulses and rate of development of stress-waves propagation	Fourier Transform (FT), Short Time Frequency Transform (STFT), Wavelet Transform (WT), etc.
Gear	Manufacturing error, tooth missing, tooth pitting/spall, gear crack, gear fatigue/wear	High noise; high dynamic; signal modulated with other factors (bearing, shaft, transmission path effect); gear specs need to be known	Time domain statistical features, vibration signature frequencies, oil debris quantity and chemical analysis	Fourier Transform (FT), Short Time Frequency Transform (STFT), Wavelet Transform (WT), etc.
Shaft	Unbalance, bend, crack, misalignment, rub	Vibration signal is relatively clean and harmonic frequency components of rotating speed can indicate the defects	Vibration characteristic frequency, time domain statistical characteristics, system modal characteristics	Fourier Transform (FT), Wavelet Transform (WT), etc.

2.2. PIPM systems

The Prognostic Inspection and Proactive Maintenance (PIPM) system is an integration of the prognostic inspection methodology and the proactive maintenance methodology. The proactive maintenance methodology entails the maintenance aspects which should be incorporated at the design stage of a physical asset, whereby all anticipated probable prospective failures are identified and removed, based on the focused historical performance of the asset, with the purpose to prescribe suitable maintenance actions at the right intervals and component parts [14]. So the PIPM system should be developed also from the design phase, especially for the regulator's Safety Evaluation in Design Certification Application (DCA) [15].

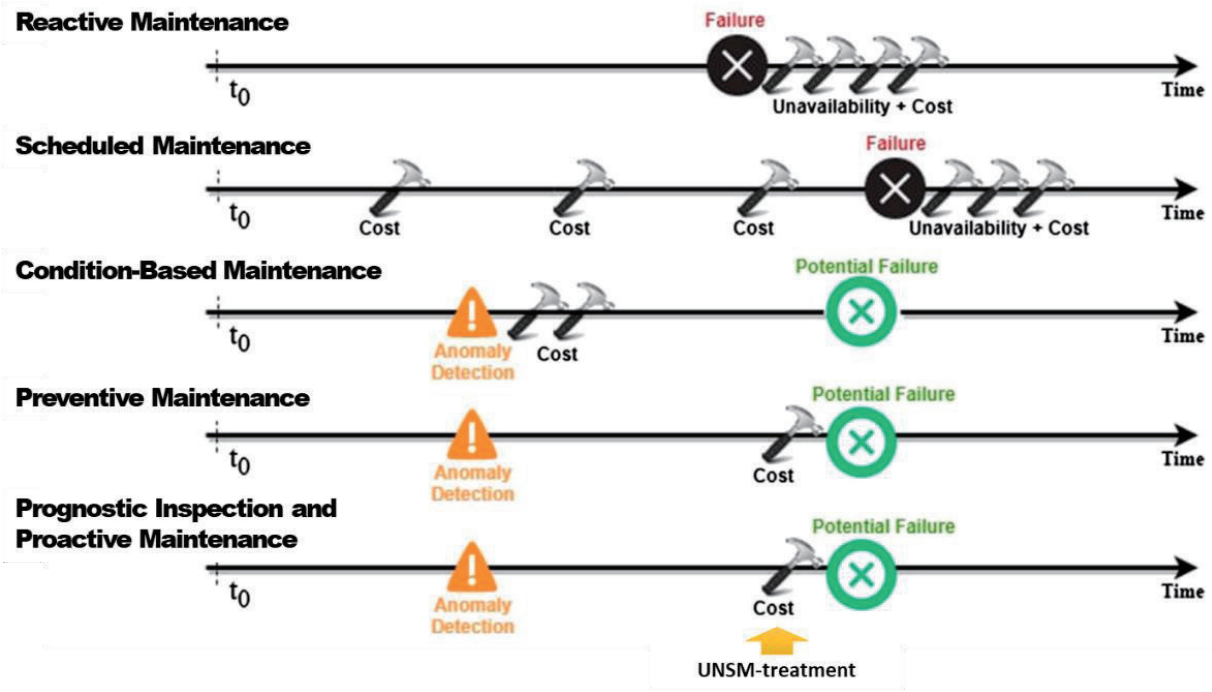


Figure 1. Scheme of the behavior of the different type maintenance approaches [4].

The concept of prognostic inspection is similar to that of CBM, which is an advanced form of preventive maintenance [1, 2]. However, an important difference lies in the measurement focus. Instead of measuring crack growth conditions, the PIPM system focuses on crack initiation conditions. To implement this, a method for measuring the condition of components at the onset of failure mode, for example, the condition of crack initiation, needs to be developed. Consideration should be given to new sensor technologies integrated with Artificial Intelligence (AI), which could be available in the future, for the development of prognostic inspection methodology. Furthermore, the remaining service life until the beginning of crack initiation should be estimated based on the results of these measurements by the analyzing function.

Proactive Maintenance involves a variety of approaches and technologies aimed at significantly reducing reactive maintenance in practice. The defining characteristic of proactive maintenance is the exploration of failure origins. Once these origins have been identified, restoration processes are implemented to eliminate the causes of the failures. Proactive maintenance is highlighted as an innovative strategic maintenance approach that aims to significantly improve the reliability and availability of components throughout their service life [16]. A proactive maintenance methodology should be developed that can be applied to components during refueling outages and could restore the fatigue strength of components to the condition of new components. Consideration should also be given to new and advanced technologies that could be available in the future as potential candidates for the proactive maintenance methodology.

Table 2. Typical examples of the PIPM system

Prognostic Inspection and Proactive Maintenance (PIPM) system		
Component	**Prognostic Inspection Methodology**	**Proactive Maintenance Methodology**
Bearing	・Sensing and Monitoring of Vibration, oil debris, Acoustic emission, Energy, Temperature, etc.: usually continuous monitoring [13] ・Measuring and Monitoring of Surface roughness, Microcracks, Hardness, Residual stress, Grain size, etc.: usually inspecting during the refueling outage [17] ・Analyzing the remaining service life till the beginning of crack initiation based on the measuring results ・Deciding whether sustaining till next or next nth refueling outage or applying the proactive maintenance	・Exchanging with the new bearings or the remanufactured bearings whose service life is equivalent to new bearing during the refueling outage [20] ・Restoring the bearings using UNSM (Ultrasonic Nanocrystal Surface Modification) technology during the refueling outage
SMR Component	・Visual inspection of discontinuities and imperfections on the CISCC (Chloride Induced Stress Corrosion Cracking) susceptible surfaces; usually measuring during the in-service inspection period [18] ・Measuring and Monitoring of Surface roughness, Residual stress, etc.: usually measuring during the in-service inspection period [19] ・Analyzing the remaining service life till the beginning of crack initiation based on the measuring results ・Deciding whether sustaining till next or next nth in-service periods or applying the proactive maintenance	・Restoring the necessary surface condition by cold splay technology or advanced surface stress improvement technology such as UNSM, Laser Peening, etc. in ASME Code & Case N931 [21]

3. Concluding Remarks

The PIPM system is a concept that integrates prognostic inspection methodology and proactive maintenance methodology. The PIPM system can enhance the lifespan and performance of target components in the current PHM through advanced restoration technology. This is an eco-friendly system that pursues a circular economy model. However, a prognostic inspection method that can detect the state of component before cracking begins must be developed. It is expected that the advanced PIPM system will be applied as a technology needed for SMR preventive maintenance in the future.

References

1. Vogl, G. W., Weiss, B. A. and Donmez, M. A. Standards Related to Prognostics and Health Management (PHM) for Manufacturing. In *NIST Interagency/Internal Report–8012* (NIST, 2014).
2. Soualhi, A., Lamraoui, M., Elyousfi, B. and Razik, H. PHM SURVEY: Implementation of Prognostic Methods for Monitoring Industrial Systems. *Energies 15*, 6909 (2022).
3. Hofmeister, J. P. Prognostic Health Monitoring Overview & Theory of Operation (Ridgetop Group, 2019).
4. Biggio, L. and Kastanis, I. Prognostics and Health Management of Industrial Assets: Current Progress and Road Ahead. *Front. Artif. Intell. 3*, 578613 (2020).
5. Gotadki, R. Population health management market Research Report. http://www.marketresearchfuture.com/reports/population-health-management-market-3123 (accessed on 01 January 2024).
6. DataM Intelligence, Global Population Health Management Market 2023-2030. https://www.giikorea.co.kr/report/dmin1316295-global-population-health-management-market.html?CODE=dmin1316295-global-population-health-management-market.html&TYPE=0 (accessed on 04 August 2023).
7. Bodaghi, A., Fattahi, N. and Ramazani, A. Biomarkers: Promising and valuable tools towards diagnosis, prognosis and treatment of Covid-19 and other diseases. *Heliyon 9*(2), e13323 (2023).
8. Sandø, A. et al. Introduction of a prognostic biomarker to strengthen risk stratification of acutely admitted patients: rationale and design of the TRIAGE III cluster randomized interventional trial. *Scand J Trauma Resusc Emerg Med 24*, 100 (2016).
9. Kumar, P., Raouf, I. and Kim, H. S. Review on prognostics and health management in smart factory: From conventional to deep learning perspectives. *Engineering Applications of Artificial Intelligence 126*, 107126 (2023).
10. Swanson, L. Linking maintenance strategies to performance. *Int. J. Prod. Econ. 70*, 237-244 (2001).

11. Kim, S. Choi, J.-H. and Kim, N.H. Challenges and Opportunities of System-Level Prognostics. *Sensors 21*, 7655 (2021).
12. Wesendrup, K. and Hellingrath, B. A Process-based Review of Post-Prognostics Decision-Making. PHM Society European Conference, Virtual Conference (27-31 July 2020).
13. Lee, J. et al. Prognostics and health management design for rotary machinery systems—Reviews, methodology and applications. *Mechanical Systems and Signal Processing 42*, 314-334 (2014).
14. Chaïb, R. et al. Failure: a source of progress in maintenance and design, *Physics Procedia 55*, 185-191 (2014).
15. https://www.nrc.gov/docs/ML1919/ML19191A196.html (accessed on 4 December 2019).
16. Papic, L., Aronov, J. and Pantelic, M. Safety Based Maintenance Concept. *International Journal of Reliability, Quality and Safety Engineering 16*(6), 533–549 (2009).
17. Kim, J., Cho, I. and Pyun, Y. A Prognostic Inspection and Proactive Maintenance System (PIPM) to Bring Snowball Effects on the Transition to the Circular Economy and a Carbon-Neutral Society. *The journal of Hyojeong Academia* (2023).
18. Code and Case N-860, Inspection Requirements and Evaluation Standards for Spent Nuclear Fuel Storage Section XI Division 1 and Division 2, ASME
19. Broussard, J. E. Technical Basis Summary for Code Case N-860: Inspection Requirements and Evaluation Standards for Spent Nuclear Fuel Storage and Transportation Containment Systems. PVP2021-64176, Virtual, Online (13-15 July 2021).
20. Darisuren, S. et al. Remanufacturing process and improvement in fatigue life of spherical roller bearings. *Journal of KSTLE 30*(6), 350-355 (2014).
21. Kim, J., Cho, I., Pyun, Y. and Amanov, A. Code Case N-931 and UNSM Technology for the Improving Service Life and Safety of Nuclear Power Plant, The 2nd International Conference of Hyojeong Academy 2023, Asan, Korea (Aug. 31-Sep. 2 2023)

Proceedings of
THE 3rd INTERNATIONAL CONFERENCE OF
HYOJEONG ACADEMY 2024

Session 4

African Studies

www.lchja.org

Indigenous Religious Perspectives to Climate Change for Co-Existence and Co-prosperity in Africa

Dorcas Chebet Juma

Pwani University, Kilifi, Keyna
Correspondence: dorcaschebetjuma@gmail.com

Abstract: In many African communities, indigenous traditional Knowledge is essential in predicting weather extremes and in helping communities to prepare for and address the adverse impacts of natural calamities like drought and floods. Indigenous religious perspectives are arguably an integral aspect that can inform climate-resilient agricultural technique and policies if a holistic approach to climate change for food security, co-existence and co-prosperity must be taken seriously. African women are custodians of indigenous religious knowledge. In pre-colonial Africa, women were the major authorities in herbal remedies within their own homes and at the community level, where they focused on disease prevention and cure. In African communities, women ritually design and implementing traditional health systems using traditional medicines and ancestral spiritual procession. Through indigenous religious knowledge, African women herbalists helped communities to interpret climate change using religious community's native ethical concepts. They enabled community members to recognize Mother Earth as a living being to whom human beings have an indivisible, interdependent, complementary, spiritual relationship and divine responsibility towards life sustainability. This paper uses an ecofeminism approach to argue that there is need to widely recognize and promote African women's indigenous religious knowledge on climate change for food security in African's co-existence and co-prosperity.

Keywords: Indigenous Religious perspectives, climate change, co-existence, co-prosperity, ecofeminism, food security, Mother Earth

1. Introduction

The worldview of many indigenous communities around the world see Mother Earth as a sacred entity hence maintain deep connections to their natural environments through indigenous religious perspectives to Mother Earth, the environment in particular and the climate in general [1]. Indigenous traditional knowledge is understandings, skills, and philosophies developed by local communities with long histories and experiences of interaction with their natural surroundings. Indigenous knowledge is knowledge, which is spatially, and culturally context specific, collective, holistic, and adaptive [2]. Indigenous Religious Knowledge (IRK) on the other hand is a category used in the study of religion to demarcate the religious belief systems of communities described as being "indigenous" [3]. In the African cosmology, there is a strong believe in the interactions between the physical and the spiritual when it comes to existence and life continuity. In African cosmology, Mother Earth is sacred and the existence of humanity depends on how human beings treat Mother Earth. The African worldview has a strong belief in the reality and power of a supreme being who influences human affairs and the metaphysical. Notably, at the core of the African genius is an exceptional religiosity with a strong belief in the existence of the supreme being or a power from whom all good things come [4]. Thus, the African indigenous religious knowledge is an embodiment of a social interaction between African communities, their environment and human experiences conceived through metaphysical realm that have evolved into the cultural ways of life over time. The African indigenous knowledge systems reveal a deep-seated connection with religious beliefs and practices expressed in a series of knowledge creating activities in philosophy, anthropology, psychology, medicine, agriculture, education, arts and crafts, music and literature [5]. Within the context of this paper, indigenous religious knowledge therefore refers to the philosophies, beliefs, songs, dance, traditions, customs and activities that carry with it the indigenous knowledge system unique to particular cultural settings, societies or communities.

When it comes to climate change; food security, co-existence and co-prosperity in Africa, indigenous religious knowledge can help with coping, informing and improving responses to climate change. This is because, indigenous religious knowledge is rooted in the cultural heritage and traditional knowledge of indigenous peoples

and local communities that can significantly contribute to conservation of the environment and enhance national and global action on climate change. African women are the custodians of indigenous religious knowledge as diviners, herbalists and storytellers. As the very custodians of the African indigenous religious knowledge, women grow 70% of Africa's food [6]. Some of the women for example the Naatum women's group in Laikipa, the Northern part of Kenya who live on arid land that has serious land degradation issues due to climate change have set up water harvesting structures and created resiliency. The women group transformed a barren land and gave it life, making farming possible and they are now generating income from growing aloe Vera, keeping bees, and they can feed their families every day [6]. African women religious leaders in particular have inherent indigenous religious knowledge, which they pass on from one generation to the other in different ways including when they are farming.

In an ecofeminism approach to climate change for co-existence and co-prosperity in Africa it is possible for one to arguably see the importance of recognizing and promoting African women's indigenous religious knowledge on climate change for food security, co-existence and co-prosperity in Africa. Before giving a detailed definition of what ecofeminism is, it is importance to underscore the fact that ecofeminism uses a gendered lens to analyze the aspect of co-existence between human beings and Mother Earth. A gendered lens is an approach that calls for an egalitarian, collaborative society in which there is no binary between the dominant and the vulnerable. In Romans 8:22, the groaning of the whole creation is put at the same category with a woman's pains during childbirth. In Genesis 3:16 after Adam and Eve ate the forbidden fruit in the Garden of Eden, the oppression of women's bodies came in three perspectives namely increased pain in child bearing, intense desire for her husband and male dominance over a woman's body. A gendered lens enables one to see how the oppressed female bodies and Mother Earth are instruments of crucial liberation theological discourses. It is from this perspective that one sees the relevance of using and ecofeminism to analyze indigenous religious perspectives to climate change for co-existence and co-prosperity in Africa. The strength of ecofeminism is in its exploration of the connections between women and nature in culture, economy, religion, politics, literature and iconography, and in addressing the parallels between the oppression of nature and the oppression of women [7].

2. Ecofeminism and African Women's Indigenous Religious Knowledge to Climate

Ecofeminism is a branch of feminism and political ecology [7]. The name ecofeminism was coined by French feminist Françoise d'Eaubonne in 1974, who saw the need to examine the effect of gender categories and to demonstrate the ways in which social norms exert unjust dominance over women and nature. Ecofeminism contends that unjust social norms lead to an incomplete view of the world. An ecofeminism lens advocates for an altern [8, 12] ative worldview that values Mother Earth as sacred, recognizes humanity's dependency on the natural world for co-existence and co-prosperity, and embraces all life as valuable [8]. Ecofeminism is a social literary lens that emerged from political activism and intellectual critique bringing together feminism and environmentalism. Ecofeminism argues that the domination of women and the degradation of the environment are consequences of patriarchy and capitalism [9]. It is important to underscore the fact the power is at the center of patriarchy and capitalism. From a general perspective, patriarchy is a system of society or government in which the father or eldest male is head of the family and descent is reckoned through the male line [10]. From a feminist point of view, patriarchy is a social system of male dominance over women.

Capitalism on the other hand is an economic system owned by private actors who control property in accordance with their interests; demand, supply freely and set prices in markets in a way that can serve the best interests of society. Capitalism is a western concept whose essential feature is the motive to make a profit [11]. When it comes to climate change for co-existence and co-prosperity, progressive scholars recognize the serious damage that results from a global capitalist drive. Notably, the endless efforts of private owners to expand and increase their profits force a "perpetual treadmill of production and consumption" relying mainly on fossil fuels or alternative sources of greenhouse gas emissions [12]. Thus, the increased urge to gain power that can keep facilitating production and supply continues to threaten the co-existence between humanity and Mother Earth especially in African countries. In African countries, agriculture is an integral part of their economy and total productivity. Due to climate change, sufficient production and food supplies have been threatened because of irreversible weather fluctuations where sometimes there is experienced uncontrolled floods or extreme and prolonged drought. This is happening within the context of capitalism where there is constant demand for production and supply of production to maintain the supply and demand chain. Because the world has become a global village,

capitalism has also infiltrated African countries. Thus, a combination of patriarchy and capitalism is having devastating consequences on the issue of co-existence and co-prosperity between humanity and Mother Earth.

Arguably, patriarchy and capitalism are interdependent system of oppression that are dependent on the accumulation of power and the oppression of the vulnerable [13]. In the Bible, the Jewish religious and patriarchal society; Genesis 1:28, 3:16 and Romans 8:22 puts the vulnerability of Mother Earth and women's bodies at the same level. In the interpretation of the texts provided in this paper, one argues that patriarchy and capitalism combine to sustain and maintain the status quo. Genesis 1:28 gives humanity the power to rule over all the creation. Genesis 1:28 is supposed to understood from the perspective of stewardship of Mother Earth. However, the application of the text continues to display a capitalistic tendency of exploitation of Mother Earth to maximize profit. The statement "he shall rule over you" in Genesis, 3:16 has been interpreted in patriarchal societies like Kenya to imply a biblical command for men to dominate women. Thus, when one encounters the voice of Paul in Roman's 8:22, it is possible to argue that the vulnerability of women's bodies is at the same level with that of Mother Earth. Capitalism and patriarchy continues to increase women's economic vulnerability by excluding middle and lower class women by perpetuating existing power imbalance and widening Gender disparity [13]. The use of the concept Mother Earth therefor seeks to use ecofeminism to underscore motherhood as the essential trait of women with innate functions of resilient, adaptive, protective, nurturing and caring instincts.

Thus, using an ecofeminism lens to argue for the need to promote African women's indigenous religious knowledge to climate change for co-existence and co-prosperity brings with it a blend of an afro-feminist approach to issues of climate change. Afro-feminist lens is a hermeneutical approach rooted in black feminism as an ideology of liberation that takes serious black women's experience, with the aim of disrupting power structures, destabilizing the status quo and challenging oppressive structures that deny God's people the right to live with dignity [14]. In Romans 8:22, the whole Mother Earth is depicted as groaning like a mother who is in labor pains eagerly waiting for liberation. The liberation of an expectant mother comes when she gives birth. In the same way, the liberation of Mother Earth is realized when the dominance of humanity over creation is transformed into social aspects of stewardship. In Genesis 2:26, God created humanity in God's image and likeness and gave humanity the power to rule over the fish in the sea and the birds in the sky the livestock, all the wild animals, and over all the creatures that move along the ground. The ruling aspect should be understood from the perspective of nurturing. African women have an innate indigenous religious knowledge of caring for the environment. Many of the African women religious leaders for example, have a full circle of religious knowledge that touches on food production, distribution, cooking, the digestive process and the disposal process. This knowledge directly links Mother Earth's reproductive system and a woman's sexual reproductive knowledge.

During food production for example, some African communities aided by African women religious leaders observe certain ritual practices directly attached to a woman's sexual reproductive system called the ritual of purification [15]. When a man must have sex with his wife during planting season for example, certain ritual observances are performed that are believed to influence the harvest positively because sex in many African communities holds a special role that goes beyond just siring children and enjoyment.

When a woman gives birth, the placenta is buried in a special way guided by a female religious leader of a given community following the cultural practices of a particular community to connect the womb of a woman with Mother Earth for life sustainability [16]. In many African societies the placenta is highly revered because of its biological and spiritual connection to a child's life cycle. The people endowed with the indigenous religious knowledge that connects the placenta to Mother Earth for co-existence and life sustainability are the biological mothers or mothers-in-law. If something goes wrong and the community starts to experience drought, floods or any natural calamity, the community will seek the indulgence of the elderly women to inquire if something went wrong during the burial of a placenta in case of new births in the community. This is because, the knowledge to understand the times and seasons of the whether are entrusted with women who are believed to have innate knowledge on such matters [17]. Thus, seven weeks after every childbirth in many Africa communities are very important. This is the time when the Ubuntu spirit takes over the whole community to raise a child by protecting the life of the Mother and ensuring that all rituals related to childbirth are observed for the better of the whole society. This is also the time when the biological mother and the Mother in-law teach the mother of the newly born child matters related to the placenta, the sacredness of the placenta and her connection to Mother Earth for co-existence and co-prosperity. The sacredness of the placenta is in the aspect of communal living and togetherness that are central elements of many African societies and cultures. This is because the placenta is a sacred organ that connects the child to the ancestors, spirits and Mother Earth for protection [18].

In many African communities, spiritual processes such as brewing of traditional beer called *Busaa* for rituals such as burials and circumcision ceremonies are conducted by women. At the heart of what enhances the community ritual ceremonies is environmental conversation for life sustainability. Ceremonies that are done to sustain the spirit of Ubuntu such as childbirth, initiation, marriage and rituals related to burial ceremonies are very dependent on food. Thus, women took on the responsibility of passing on from one generation to the other important indigenous religious knowledge on life sustainability related to the environment. This is done through song and dance, poems the type of food shared during the ceremonies, herbal treatments used to embalm the bodies of the dead and treatment administered to the circumcised candidate. That is why, in response to challenges that rural Kenyan women were facing in regards to food security for example, Wangari Maathai (1940-2011) the founder of the Green Belt Movement (GBM) and the 2004 Nobel Peace Prize Laureate, empowered rural women to conserve the environment through ecofriendly farming systems that had a long-term resilient response to climate change and food security. Using GBM Maathai promoted African cultural diversity while embodying indigenous religious knowledge as a response to climate change and food security [19]. It is from this perspective that one sees the need to earnest African women's indigenous religious knowledge to climate change. One therefore asks why is women's indigenous religious knowledge to climate change for co-existence, co-prosperity and food security in Africa important.

Firstly, it is the responsibility of every Africa mother to teach her children to respect Mother Earth and all that dwell in her. Every African mother is supposed to teach her children the laws of nature and help them understand the cosmic rhythms. The African spiritual worldview is deeply rooted in respect for nature, reverence for hills, forests, animals, and rivers because African spirituality is communicated through the environment. At the center of African spirituality is a strong aspect of deep human values, attitudes, beliefs and practices that arise from the fact that the African traditional knowledge systems teaches community members to worship and venerated everything under the earth, on earth, between the earth and heavens and in the heavens above [20]. Notably, the knowledge of various methods that help to restrict the utilization of certain natural resources is with women as the custodians of African indigenous knowledge. Thus, the women teach their children methods of protecting and maintaining God's creation through the African belief systems as a way of conserving the environment.

Secondly, the African women's belief system develops out of her active engagement in the generational acquisition and classification of knowledge within their linguistic, cultural, economic, ecological, and sociological world. This naturally happens through the long chain of transmitting the traditional knowledge system from one generation to the other. Using song, dance and poems for example, African women communicate(d) and express(ed) the environmental wisdom, ethics and religious beliefs that are very useful in natural resource management. The knowledge transmission touches on traditional natural resource management in classified categories such as protection of particular ecosystems or habitats such as sacred groves and sacred rivers, ponds, particular animals or plant species such as totem and tabooed species, trees, forests, wildlife and marine organisms. The innate characteristics of Mothering in women's traditional conservation ethics are capable of protecting biodiversity species in particular and the environment in general as long as there is keen interest to earnest women's religious indigenous knowledge on the ecosystem. This is because, the traditional ecological knowledge (TEK) systems are infused with practices and concepts, and modes of teaching and learning that can be related directly and indirectly to resource stewardship and conservation at various spheres of life [21].

Thus, a blend of ecofeminism and African women's indigenous religious knowledge to climate change furthers a reconstruction of women's contributions to the intersection of feminist theory and environmental protection. An outstanding example of a blend of ecofeminism and African women's indigenous religious knowledge to climate change is the remarkable work of the Kenyan scientist, feminist, ecological and political activist Maathai the winner of the Nobel Peace Prize in 2004 [22]. Maathai put African women's indigenous religious knowledge to climate change in her approach to the environmental protection and poverty reduction in the rural areas of Kenya. In her innate motherly wisdom, Maathai identified the link between environmental degradation and poverty in Kenya. Notably, deforestation had dramatically affected local village life by heavily influencing food security, health, water sources, the economy, and women. Using the Green Belt Movement, Maathai focused on reforestation to promote sustainability and establish financial income for women in the region as a way of mitigating gendered poverty through an ecofeminism approach to the environment. Mother Earth symbolizes the environment in which life thrives [23]. African women are connected to Mother Earth, land and the environment hence the need to reclaim the spiritual union between women's indigenous religious knowledge to climate change for co-existence, co-prosperity and food security in Africa.

3. Indigenous Religious Perspectives, Co-Existence and Co-prosperity

Religion remains central to the lives of the African people. Traditional African religions are lived religions whose central aspects are rituals, traditions, and practices passed down via oral tradition influencing all aspects of daily life, such as diet, healthcare, work schedule, and dress.

The African religious worldview is primarily indigenous in her transitive approach to life, theologies and knowledge systems. Because of the African philosophy of Ubuntu, indigenous religious perspectives inform the aspect of coexistence and prosperity between Mother Earth and humanity. African religions emphasize maintaining a harmonious relationship with the divine powers, and their rituals attempt to harness cosmic powers for co-existence and co-prosperity. Many indigenous belief systems are rooted in a holistic understanding of the world with an innate believe that the well-being of the community is connected to the health of the environment and Mother Earth. That is why indigenous cultures for example embrace traditional medicine as the best form of healthcare in many parts of the world. This is because it has a more holistic approach to healing, including the interconnection of mind, body, and spirit in a specific contexts [23]. In many African communities, cultural practices and community rituals especially those that relate to birth, initiation, marriage, death and burial ceremonies often reflect a balance between human needs and environmental sustainability.

Thus, indigenous religious perspectives emphasize harmony between human beings and the natural world in ways that creates interconnectedness, and a deep respect for Mother Earth. In many African communities, religions are intimately tied to Mother Earth. Traditional tribal values contain intrinsic themes of ecological interconnectedness to guide reciprocal relationships with the environment and the natural world. While deferent African societies have diverse and dynamic tribal ways of life, an inter and intra-tribal commonality way of life for co-existence and prosperity exists that is expressed through the reverence of Mother Earth. African societies hold Land and natural habitats with the highest spiritual meaning because of the believe that the spirits of the deceased are said to reside in natural areas making communities assigned higher priority to regulating ways of interacting with the natural habitats [24]. Values of spatial-based and temporal based religions produce fundamental differences of great philosophical importance between the spiritual world and the world of the living. Sacred sites continue to be used by many African communities for religious initiation ceremonies, pouring of libation and offering of sacrifices, and divination. Therefore, within the context of this scholarly discussion therefore, co-existence and co-prosperity involves not just living alongside others but also fostering a mutual relationship between human beings and Mother Earth.

The effects of climate change can holistically be dealt with, when empowerment strategies for co-existence and prosperity target every individual, family, social and religious institutions, and nation to continuously keep generating ideas and deploying them for increasing wealth extraction from natural resources while causing less harm. Indigenous religious perspectives and cultural values on matters nature are foundations of beliefs transferred through individuals, social institutions and family systems. From a young age, communities socialized individuals to their cultural and religious beliefs concerning the natural world. Elders and community members often play a crucial role in passing down this knowledge to the younger generation [25]. Fundamental social values vary between diverse populations, yet it is important to identify core value-orientations shared amongst cultures that can help in the fight against climate change for co-existence and prosperity. In many African communities, indigenous traditional Knowledge is essential in predicting weather extremes. Religious community leaders, especial women diviners often possess a deep understanding of their local environments, including subtle signs in nature that can indicate impending weather changes. The women diviners rely on keen observation of natural signs, such as the behavior of animals, the appearance of certain plants, or changes in the sky, the movement or calls of certain birds might which is often interpreted as a predictor of rainfall [26]. The mating of certain animals and flowering of certain plants are all understood as important signals of changes in time and whether conditions.

The calendar of the African whether is marked by traditional knowledge innately possessed by women diviners which is based on the observation of recurring patterns in nature used to guide agricultural practices and to help communities determine the best times for planting and harvesting crops [27]. Some community rituals and ceremonies are directly linked to specific seasons or weather patterns informed by the understanding of the natural environment and its cycles. Women being the custodians of the indigenous traditional knowledge shared their knowledge with younger generations through storytelling, passing down not just the practical aspects but also the cultural and spiritual significance of weather patterns. Fostering a mutual relationship between human beings and Mother Earth involves a holistic approach that integrates ecological sustainability, cultural respect,

and spiritual awareness. Thus, a positive step towards indigenous religious perspectives to climate change for co-existence and co-prosperity in Africa should take into consideration the following issues:

Firstly, there is need to promote awareness and understanding of ecological principles which emphasize the interconnectedness of the life of humanity and Mother Earth. A reciprocal relationship between Mother Earth and humanity is important in facilitating grounding breaking insights on how to live in sustainable, peaceful and respectful ways with Mother Earth's biodiversity. The awareness should therefore be done in such a way that instills a sense of responsibility and respect for the environment. While there are some negative cultural values in the African traditional society, which prevents life from flourishing, there is need to sensitize community members to adapt a sense of cultural appreciation that acknowledges and respects diverse cultural perspectives, including indigenous religious knowledge and practices that are prolife. Learning from traditional wisdom can provide valuable insights into sustainable living and a harmonious relationship with Mother Earth. Teaching the current generation to be conscious of the impact of each individual's actions on several generations to come is very important. One of the main sustainable practices for co-existence and prosperity is to encourage and adopt sustainable practices in daily life, such as reducing waste, conserving energy, and supporting eco-friendly initiatives.

Secondly, there is need to socialize communities and individuals to voluntarily support and participate in indigenous religious conservation initiatives that aim to protecting and restoring natural habitats. This should be done by socializing community members to actively participating in local environmental projects or contributing to organizations focused on conservation efforts such as the initiative of GBM by Maathai. Assuming role of her mother for example, Maathai's daughter carries on her mother's bold fight for green spaces in Kenya by empowering the youth in Kenya to lead the struggle to protect the environment. In her efforts, one sees a strong aspect of building communities that value and prioritize environmental sustainability. Additionally, the fact that african women are custodians of indigenous religious education offers the contemporary society as asset to intergrate wisdom sharing that facilitates the exchange of knowledge between generations. Elderly women often hold valuable insights into traditional practices that promote a harmonious relationship with the Earth. This intergenerational wisdom can be a powerful resource for building a sustainable future. Fostering a mutual relationship with Mother Earth is a collective effort that requires a shift in mindset and behavior at both individual and societal levels.

4. Conclusion

The issues of co-existence, co-prosperity and food security in Africa is directly linked to the vital role that African women play in addressing climate change through indigenous religious perspectives. Since African women are custodians and transmitters of indigenous religious knowledge, there is need to promote African women's indigenous religious knowledge on climate change as a powerful and necessary initiative. Women in many African communities often play key roles in natural resource management, agriculture, and maintaining community well-being especially through herbal medicine and community ceremonies and rituals. Building on the general foundation of indigenous religious perspectives for co-existence and co-prosperity, there is need to empower women within communities by providing platforms for sharing their knowledge through storytelling events, or ritual and community bases ceremonies that leverage their expertise in sustainable practices and mutual existence with Mother Earth. In fact, there is need to revise curriculums in educational institutions and create room to for the educational programs to highlight the intersection of indigenous religious knowledge, women's roles, and climate change.

References

1. Sandhu, H. and Gibbons, D. Centering Indigenous Worldviews in Environmental Education. *Revue de l'éducation-Education Journal 36*
2. Ghorbani, M., Eskandari-Damaneh, H., Cotton, M., Ghoochani, O.M., and Borji, M. Harnessing indigenous knowledge for climate change-resilient water management – lessons from an ethnographic case study in Iran. *Climate and Development 13*(*9*), 766–79 (2021).
3. Yountae, A. A decolonial theory of religion: Race, coloniality, and secularity in the Americas. *Journal of the American Academy of Religion 88*(4), 947–80 (2020).
4. Kanu, I. A. On the origin and principles of Igwebuike philosophy. *Journal of Religion and Human Relations 11*(1), 159–76 (2019).
5. Falola, T. African Traditional Religion and Indigenous Knowledge System. In *The Palgrave Handbook of African Traditional Religion* (Springer International Publishing, 2022).

6. Women Who Farm Africa. https://allianceforscience.org/women-who-farm-africa/ (accessed on 23 Dec 2023).
7. Ecofeminism. https://en.wikipedia.org/w/index.php?title=Ecofeminism&oldid=1187224350 (accessed 23 Dec 2023).
8. Ecofeminism | Sociology, Environmentalism & Gender Equality. https://www.britannica.com/topic/ecofeminism (accessed on 24 Dec 2024).
9. Ecofeminism - an overview. https://www.sciencedirect.com/topics/social-sciences/ecofeminism (accessed on 23 Dec 2023).
10. PATRIARCHY Definition & Usage Examples. https://www.dictionary.com/browse/patriarchy (accessed 24 Dec 2023).
11. What Is Capitalism? - Back to Basics - Finance & Development, June 2015. https://www.imf.org/external/pubs/ft/fandd/2015/06/basics.htm (accessed on 26 Dec 2023).
12. How Capitalism is a Driving Force of Climate Change – PIT Journal. https://pitjournal.unc.edu/2022/12/24/how-capitalism-is-a-driving-force-of-climate-change/ (accessed on 26 Dec 2023).
13. Folbre N. The rise and decline of patriarchal systems: An intersectional political economy https://books.google.com/books?hl=en&lr=&id=1dUXEAAAQBAJ&oi=fnd&pg=PT8&dq=patriarchy+and+capitalism+are+interdependent+system+of+oppression+that+are+dependent+on+the+accumulation+of+power+and+the+oppression+of+the+vulnerable&ots=DiuAKX6H5d&sig=hJzfW6qm-opWUPa79GCBdwNI_NQ (accessed on 26 Dec 2023).
14. Juma, D. C. Proverbs 31 in dialogue with Acts 9: 36-43: An Afro-feminisation of Mother Earth for equity. *HTS Theological Studies 79*(3), 1–7 (2023).
15. Nabofa, M. Y. Blood Symbolism in African Religion. *Religious Studies 21*(3), 389–405 (1985).
16. Muhonja, B. B. Dimensions of Motherhood in an African World Sense. Gender and Sexuality in Kenyan Societies: Centering the Human and the Humane in Critical Studies. 2022;153.
17. Lawson, E. T., Alare, R. S., Salifu, A. R. Z. Thompson-Hall M. Dealing with climate change in semi-arid Ghana: understanding intersectional perceptions and adaptation strategies of women farmers. *GeoJournal 85*(2), 439–52 (2020).
18. Moeti, C., Mulaudzi., F.M., Rasweswe, M. M. The Disposal of Placenta among Indigenous Groups Globally: An Integrative Literature Review. International Journal of Reproductive Medicine. https://www.hindawi.com/journals/ijrmed/2023/6676809/ (accessed on 26 Dec 2023).
19. Muchiri, M. One Woman's Struggle. Global Servant-Leadership: Wisdom, Love, and Legitimate Power in the Age of Chaos. 2020;151.
20. Communicating African Spirituality through Ecology: Challenges and Prospects for the 21st Century. https://ir-library.ku.ac.ke/handle/123456789/17982 (accessed on 28 Dec 2023).
21. Rim-Rukeh A, Irerhievwie G, Agbozu IE. Traditional beliefs and conservation of natural resources: Evidences from selected communities in Delta State, Nigeria.
22. Ecofeminism in Africa: The Contribution of Wangari Maathai | The Consortium on Gender, Security and Human Rights. https://genderandsecurity.org/projects-resources/research/ecofeminism-africa-contribution-wangari-maathai (accessed on 28 Dec 2023).
23. Chireshe, E. The liberation of women and girls as the liberation of Mother Earth: A theological discourse. *HTS Theological Studies 79*(3) (2023).
24. Constant, N. L. and Taylor, P. J. Restoring the forest revives our culture: Ecosystem services and values for ecological restoration across the rural-urban nexus in South Africa. *Forest Policy and Economics 118*, 102222 (2020).
25. McAnirlin, O. and Maddox, C. B. 'We have to be a little more realistic': women's outdoor recreation experiences in a community hiking group. *Annals of Leisure Research 25*(3), 335–51 (2022).
26. Kozub, M., Krzyżak, Z., Kwiatkowska, M. and Serwin, Z. The Role of Nature in Ancient Divination in the Light of Cicero's De divinatione. *cognoscere causas178*.
27. Mji, G. Women as healers and indigenous knowledge systems and its holders: An intertwined epistemological and ontological struggle for recognition. https://europepmc.org/books/nbk559870 (accessed on 30 Dec 2023).

Analyzing Future Environmental Trends and Impacts of Landfills in Africa: A Comprehensive Re-view

Ali Adan[1,*] and Andy C. Matata[2]

[1] Technical University of Kenya, Nairobi, Kenya
[2] Catholic University of Eastern Africa, Nairobi, Kenya
*Correspondence: aadan@umma.ac.ke

Abstract: This study endeavors to assess the prospective environmental ramifications of landfills in Africa, recognizing their widespread global application in waste disposal. Landfills pose formidable challenges by emitting potent greenhouse gases, including methane, carbon dioxide, and nitrous oxide, during the decomposition of organic waste. Moreover, the generation of leachate, a hazardous liquid byproduct, poses a substantial threat to soil, groundwater, and ecosystems. In light of population growth, urbanization, and deficient waste infrastructure, these challenges are poised to intensify. The research explores evolving trends and technologies, with a particular emphasis on the escalating emphasis on waste reduction and recycling to divert refuse from landfills. Viable recycling systems and advancements in landfill design and management practices emerge as prospective solutions. Employing mixed methods, qualitative data is acquired through interviews and focus group discussions involving experts, policymakers, and industry professionals. Simultaneously, quantitative data pertaining to waste generation, disposal trends, and environmental metrics are meticulously gathered from authoritative sources. The findings elucidate that, despite being deemed the optimal technological recourse for Africa, landfills encounter impediments stemming from public sentiment, spatial limitations, deficient management, apprehensions regarding pollution, and constrained resource recovery capacity. Proposals for holistic approaches, encompassing educational campaigns and community engagement, are posited to mitigate the adverse impacts of landfills. The study accentuates the imperative reliance on waste reduction, technological innovations, alternative management methodologies, and public involvement to shape the trajectory of the future. While a comprehensive departure from landfills may prove challenging, particularly in resource-constrained regions like Africa, sustained research and investment in sustainable waste management strategies are deemed indispensable for a more ecologically sustainable future. The study advocates for a judicious equilibrium, wherein efforts to alleviate landfill impacts coalesce with the exploration of sustainable alternatives, fostering a resilient and ecologically prudent waste management paradigm.

Keywords: landfills, waste, recycling, technology, Africa

1. Introduction

Allergic Landfills are a common element of waste management systems all across the world, including Africa. As the continent's population grows and urbanizes, the amount of trash produced grows dramatically, providing substantial difficulties to environmental sustainability. Given these concerns, it is critical to examine future environmental trends and predict the potential implications of African landfills [1]. The purpose of this research is to give a complete overview of the existing situation of landfills in Africa as well as an analysis of their potential future environmental repercussions. This research intends to identify major trends and patterns in landfill growth, waste composition, and environmental repercussions in the African context by evaluating current literature, reports, and case studies.

The research will cover a wide range of topics, including the social, economic, and environmental aspects of landfill management. This study will offer light on the underlying reasons of Africa's rising garbage dilemma by evaluating the socioeconomic variables driving landfill expansion, such as fast urbanization, population increase, and changing consumer habits.

Furthermore, the study will look into the environmental repercussions of landfills, such as air and water pollution, soil degradation, greenhouse gas emissions, and negative effects on species and ecosystems. The study

aims to provide a thorough understanding of the potential long-term effects of landfill development in Africa by investigating these factors.

In addition to identifying landfill concerns, this research will look into potential solutions and best practices for sustainable waste management. This will entail investigating innovative technology, regulations, and tactics that have successfully minimized the negative environmental impacts of landfills in other locations [2].

The study's findings are likely to add to the body of knowledge on landfill management in Africa and give significant insights for policymakers, waste management practitioners, and environmentalists. Stakeholders can design educated plans to promote sustainable waste management practices, reduce environmental degradation, and protect the well-being of African populations by understanding future environmental trends and landfill impacts.

1.1. Statement of the Problem

According to studies [3], landfill proliferation and its associated environmental repercussions pose substantial problems to Africa's sustainable waste management. The continent's fast urbanization, population growth, and changing consumption patterns have all contributed to an increase in trash generation, putting a pressure on existing waste management systems [4]. To address this important issue, a qualitative study was done to investigate the future environmental trends and repercussions of African landfills, as well as prospective solutions for sustainable waste management.

The study addresses the issue of a lack of thorough information of future environmental trends and repercussions of landfills in Africa. While landfills are essential for waste disposal, their expansion and management practices can have a negative impact on the environment, human health, and ecosystems. The specific subject to be investigated is the need to determine the landfill development drivers, waste composition, environmental repercussions, and socioeconomic factors impacting landfill growth in Africa. Furthermore, the project intends to investigate alternative solutions and best practices for sustainable waste management on the continent.

1.2. Hypothesis

Based on the literature and observations, the premise of this qualitative study is that growing urbanization, population growth, and changing consumption patterns are driving landfill expansion in Africa. Organic garbage, plastics, hazardous items, and e-waste are predicted to make up a sizable part of waste in African landfills. Landfills are expected to have negative environmental effects such as air and water pollution, soil deterioration, greenhouse gas emissions, and impairment to surrounding ecosystems. Government regulations, economic incentives, waste management infrastructure, and public awareness and engagement are thought to play an important influence in landfill development and waste management practices in Africa. The study also hopes to discover viable answers and best practices from other regions that might be applied to the situation in Africa.

This research aims to contribute to the knowledge base on landfill management and environmental sustainability in Africa by conducting a qualitative study and examining these hypotheses, as well as provide insights for policymakers, waste management practitioners, and environmentalists to address the challenges and work toward sustainable waste management practices on the continent.

2. Materials and Methods

Various materials and methods shall be used to ensure the success and the accessibility of this study. The materials to be used shall consist of:

2.1 Study Design

A comprehensive review methodology will be used in this study to examine future environmental trends and repercussions of landfills in Africa. A systematic evaluation of current literature, papers, and case studies on landfill management and environmental implications in Africa will be conducted as part of the research.

2.2 Data Collection

Accessing and reviewing relevant scholarly articles, government reports, international organization publications, and case studies from reliable sources will be part of the data collection process. Data will be gathered using a variety of internet venues, including academic journals, research databases, and institutional repositories. Fur-

thermore, papers and publications from government agencies, environmental organizations, and waste management authorities will be studied in order to collect relevant data on landfill development, waste composition, and environmental repercussions.

2.3 Inclusion and Exclusion Criteria

Specific inclusion and exclusion criteria will be created to verify the data's quality and usefulness. Only research and papers focusing on landfills in Africa and providing insights into future environmental trends and implications will be considered. Priority will be given to peer-reviewed articles, government reports, and case studies published in the last decade, that is between 2013 and 2023.

2.4 Data Analysis

The information gathered will be examined using qualitative research methodologies. To uncover major trends, patterns, and commonalities in landfill development, waste composition, and environmental impacts across Africa, a theme analysis technique will be used. The data will be categorized and organized into topics and subthemes linked to the research objectives during the analysis.

2.5 Ethical Considerations

Because this study is only based on a evaluation of current literature, research approval is not required from the National Commission for Science, Technology and Innovation (NACOSTI) Kenyan. However, correct citation and acknowledgment of sources will be ensured in order to maintain academic integrity and avoid plagiarism.

2.6 Limitations

It is important to acknowledge the limitations of this study. The findings will be based solely on the available literature and reports, which may have inherent biases and limitations. Additionally, the data collected may vary in terms of quality, scope, and depth across different sources. However, efforts will be made to include a diverse range of studies and reports to minimize these limitations.

2.7 Significance

The comprehensive research technique used in this study will provide a full insight of the future environmental trends and repercussions of landfills in Africa. The findings will add to the existing body of knowledge on landfill management and environmental sustainability, providing valuable insights for policymakers, waste management practitioners, and environmentalists in developing strategies to promote sustainable waste management practices and mitigate environmental degradation in Africa.

3. Results

3.1 Trends in Landfill Development

The study will evaluate trends in landfill development across Africa, as well as the factors driving their rise, such as fast urbanization, population increase, and changing consumer patterns. It will also reveal differences in landfill infrastructure, management practices, and laws.

3.2 Waste Composition

The study will disclose the waste composition in African landfills, highlighting the most common types of garbage created and their possible environmental implications. Insights regarding the prevalence of organic garbage, plastics, toxic materials, and e-waste will be provided.

3.3 Environmental Impacts

The research will reveal and confirm the environmental repercussions of African landfills, such as air and water pollution, soil degradation, greenhouse gas emissions, and effects on local ecosystems and species. It will also provide a thorough grasp of the magnitude and severity of these impacts.

3.4 Socio-Economic Factors Peculiar to Africa

The study will look at the socioeconomic factors that influence landfill development and waste management practices in Africa. Examining the existing role of government regulations, economic incentives, waste management infrastructure, and public knowledge and engagement will be part of this.

3.5 Best Practices and Solutions.

The study will examine new technology, policies, and tactics that have successfully alleviated the negative environmental impacts of landfills in various regions such as South Korea, Malaysia, India, and Thailand. These best practices will be advocated in order to provide insight into prospective solutions for long-term waste management in Africa.

4. Discussion

The extensive assessment undertaken in this paper provides useful insights into the future environmental trends and repercussions of landfills in Africa. This study provides light on the issues faced by landfill expansion on the continent and proposes viable solutions for sustainable waste management by examining existing literature, bulletins, and case studies.

First, it highlights rising urbanization, population growth [5], and shifting consumer habits as primary drivers of landfill expansion in Africa. As cities expand, so does the volume of waste generated, putting strain on existing waste management systems. This conclusion underscores the significance of proactive planning and infrastructure development in meeting the expanding waste management demands in African cities [6].

Second, the study focuses on the makeup of garbage in African landfills. It cites organic waste, plastics, toxic materials, and e-waste as major contributors to environmental degradation. This research emphasizes the critical need for efficient waste separation, recycling, and disposal methods to reduce the environmental impact of these waste streams [7].

Third, the study investigates the environmental effects of landfills in Africa. It demonstrates the negative consequences of air and water pollution, soil degradation, greenhouse gas emissions, and damage to local ecosystems and species. These findings highlight the critical importance of implementing sustainable waste management strategies that reduce these impacts while also protecting the environment and public health [8].

Fourth, the socioeconomic elements that influence landfill development and waste management techniques in Africa are investigated. The study emphasizes the importance of government regulations, economic incentives, waste management infrastructure, as well as public knowledge and engagement. This study implies that attaining sustainable waste management in Africa requires a multifaceted approach combining collaboration between governments, communities, and industries [9].

Several potential research directions can be identified based on the findings of this study. First, more research is needed to investigate the specific issues that different African regions confront in managing landfills and trash. Case studies and field investigations would be conducted in order to obtain a better grasp of the local situation and generate specific solutions.

Furthermore, future research might examine the efficacy of present waste management policies and methods in Africa. This would entail examining the implementation and impact of waste reduction, recycling, and landfill management policies in order to find areas for improvement and best practices.

Furthermore, more research on innovative waste management technologies and practices in Africa is required. This could involve researching the viability and effectiveness of waste-to-energy systems, composting facilities, and decentralized waste management options to reduce landfill reliance and environmental implications.

Finally, future research might look into the social and economic aspects of garbage management in Africa. This would entail researching the socioeconomic implications of landfill growth, such as the impact on marginalized areas, the possibility for employment creation in the waste management sector, and the role of informal garbage pickers in the recycling value chain.

5. Conclusion

This detailed analysis on the future environmental trends and repercussions of landfills in Africa provides useful insights into the difficulties and potential solutions for the continent's sustainable waste management. This research identifies important drivers of landfill expansion, waste composition, environmental implications, and

socioeconomic factors impacting landfill development in Africa through a thorough examination of available literature, reports, and case studies.

The study's findings underscore the critical need for proactive waste management planning and infrastructure development to address escalating waste management demands caused by rapid urbanization, population increase, and changing consumer habits. It is critical to implement appropriate waste sorting, recycling, and disposal systems in order to reduce the environmental impacts of the most common waste streams, which include organic waste, plastics, hazardous items, and e-waste.

References

1. S. v. Niekerk and V. Weghmann, Africa and Arab Countries: Working Paper, Ferney-Voltaire Cedex, France: Public Services International, 2018.
2. H. E. Bari and C. Trois, Eds., Waste Management in Developing Countries, London: Springer, 2023.
3. H. Tammemagi, The Waste Crisis: Landfills, Incinerators, and the Search for a Sustainable Future, Oxford, UK: Oxford University Press, 2020.
4. V. Akpan and D. Olukanni, "Hazardous Waste Management: An African Overview:," Recycling, vol. 5, p. 15, 2020.
5. R. Mohee and T. Simelane, Eds., Future Directions of Municipal Solid Waste Management in Africa, Pretoria: Africa Institute of South Africa , 2015.
6. T. N. Haregu, A. K. Ziraba, I. Aboderin, D. Amugsi, K. Muindi and B. Mberu, "An assessment of the evolution of Kenya's solid waste management policies and their implementation in Nairobi and Mombasa: analysis of policies and practices," Sage Journal Environment and Urbanization, vol. 29, no. 2, pp. 515-532, 2017.
7. M. Adedara, R. Taiwo and H.-R. Bork, "Municipal Solid Waste Collection and Coverage Rates in Sub-Saharan African Countries: A Comprehensive Systematic Review and Meta-Analysis," Waste, vol. 2, no. 1, pp. 389-413, 2023.
8. L. Makarichi, K. R, W. Jutidamrongphan and K. Techato, "Suitability of municipal solid waste in African cities for thermochemical waste-to-energy conversion: The case of Harare Metropolitan City, Zimbabwe," Waste Management & Research, vol. 37, no. 1, pp. 83-94, 2019.
9. B. Assaye, Waste Management. Socio-Economic Factors affecting Solid Waste Management in Ethiopia, Munich : Grin Verlag, 2021.

3rd International Conference of Hyojeong Academy

Environmental Exposure to Air Pollutants and Respiratory Health of Congolese Stone Quarry Workers

Nlandu Roger Ngatu[1, 2,*], Leon-Ngombe Kabamba[2] and Michel-Nzaji Kabamba[2]

[1]Kagawa University Faculty of Medicine, Kagawa 761-0793, Japan.
[2]Kamina University, Kamina 293, Democratic Republic of Congo.
*Correspondence: ngatunlandu@gmail.com

Abstract: WHO considers ambient air pollution as the greatest environmental health risk. The "United Nations Environment Program (UNEP) Action Notes 2021" reported that 99% of world population live in places with atmospheric air pollutants levels above WHO's exposure limits. This report is part of "Congo O.S.H. Project 2018-2020", focusing on the respiratory health of Congolese quarry workers. This was a case-control study conducted in stone quarry sites in Katanga area, Democratic Republic of Congo (DRC). In total, 512 female workers participated in the study; 256 dust-exposed female quarry workers matched to 256 office workers and market tax collectors. They answered a respiratory health questionnaire, underwent physical examination and lung function testing. Air quality was assessed by means of an air quality monitor. Results showed a lack of personal protective equipment (PPE) in exposed women, higher $PM_{2.5}$ (205 ± 13.2 μg/m^3 vs. 31.3 ± 10.3 μg/m^3; $p < 0.001$) and volatile organic compounds (VOC, 2.2 ± 0.2 μg/m^3 vs. 0.5 ± 0.3 μg/m^3; $p < 0.01$) were observed in quarry sites. Respiratory complaints were common in exposed women (32.4% vs. 3.5%; $p < 0.01$), with reduced lung capacity (mean PEFR: 344.8 ± 2.26 vs. 405 ± 67.7 L/s; $p < 0.001$. Congolese stone quarry workers are exposed to high air pollutants levels, which might contribute to impaired lung function.

Keywords: Air pollutant, Particulate matter, Quarry worker, Respiratory health, Volatile organic compound, Women.

1. Introduction

According to the World Health Organization (WHO), environmental air pollution is one the major health threats. WHO considers ambient air pollution as the greatest environmental health threat. According to the "United Nations Environment Program (UNEP) Action Notes 2021", 99% of world population live in places with atmospheric air pollutants levels above WHO's exposure limits [1, 2]. Exposure to high particulate matter (PM) levels are associated with lung function impairment.

Petrochemical industry, open and underground mining industries, cement factory and construction industries are among the major contributors to ambient air pollution (AAP) in countries of the sub-Saharan Africa region. A few studies conducted in Nigeria showed that quarry workers with a history of chronic dust-exposure had a greater risk of developing respiratory symptoms [3, 4]; however, no study has focused on occupational safety and health of women working in stone quarry sites.

This study assessed the air quality status stone quarry sites and the respiratory health of female quarry workers in Haut-Katanga province, Democratic Republic of the Congo (DRC).

2. Materials and Methods

2.1. Study design, sites and participants

This report includes a part of the "Congo Occupational Safety and Health Project 2016-2018", focusing on the air quality monitoring in working environment and the respiratory health of dust-exposed workers in the Katanga region, DRC. Here, we present findings from a case-control study that included 256 female stone quarry workers (exposed group) and 256 female office workers and market tax collectors (control group), for a sample size of 512 participants. Katanga region is located in southern area of DRC; it is part of the African copper-belt, which also includes a part of Zambia [5] (**Fig. 1**).

Inclusion criteria were as follows: voluntary participation, having at least one year of work experience, absence of contraindication for lung function test, provide informed consent, be present at workplace on the day of examination, not participating in a similar study.

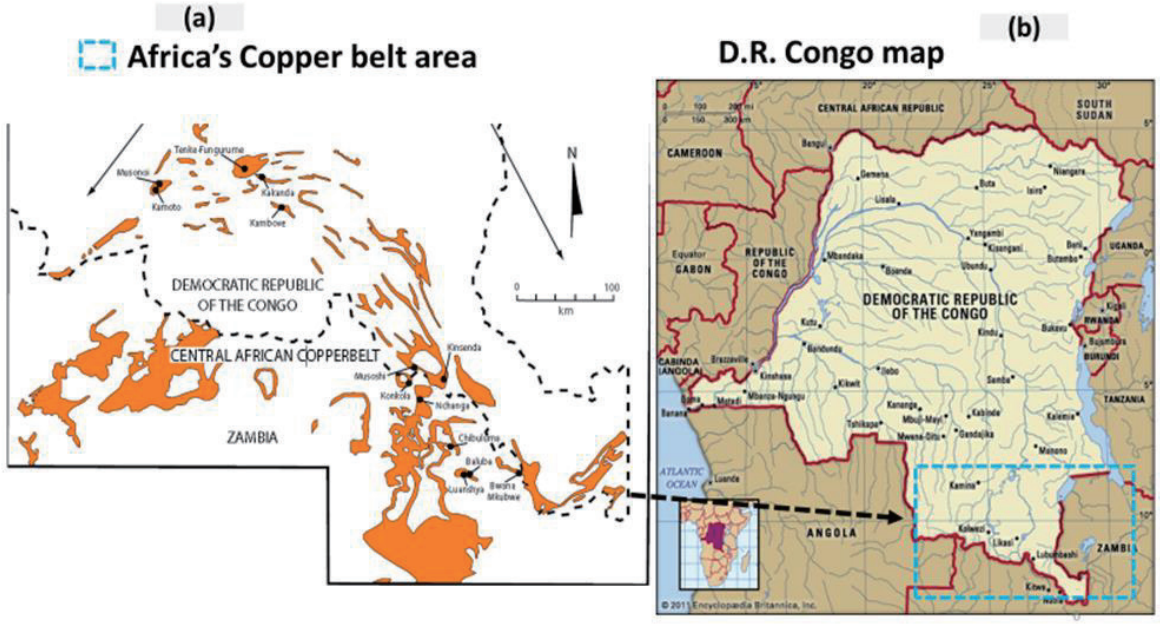


Figure 1. (a) Central African copper belt area; (b) map of the Democratic Republic of the Congo [5, 6] (Panel a and b are content in the public domain, which provenance is provided).

2.2. Survey questionnaire, lung function testing and air quality monitoring

Participants answered a structured respiratory health questionnaire, comprising questions related to anthropometric, sociodemographic and occupational characteristics, and respiratory health symptoms as well. In addition to a general medical check-up (including chest auscultation), lung function test was performed with the use of a peak flow meter, and the following parameters were considered: forced vital capacity (FVC), forced expiratory volume per second (FEV1), and peak expiratory flow rate (PEFR). Air quality assessment was carried out three times at each quarry site, with a 30-minute interval, using BRAMC air quality monitor (BR-AIR-329). Air pollutants measured were as follows: volatile organic compound (VOC), PM_{10} and $PM_{2.5}$.

2.3. Ethical consideration and statistical analysis

To participate in this study, each subject provided a written informed consent; participation was voluntary. Ethical approval was obtained from the ethics committee of the School of Public Health, University of Lubumbashi, DRC (approval number: UNILU/CEM/075/2015).

Group comparisons were performed using Student's t-test for continuous variables, whereas Fisher's exact test was used for categorical variables. Multivariate logistic regression analysis was performed, with adjustment for age, education level and smoking status, in order to determine factors associated with lung function parameters. Stata software v.14 was used for data analysis and the level of significance was set at p-value less than 0.05 (double-sided).

3. Results

3.1. Characteristics of the study participants and air quality in the working environment

As shown in Table 1, a large proportion of workers from the exposed group, 99.2% (254/256) were nonsmokers.; there were only two women smokers (0.8%) in this group (vs. 3.5% in controls; $p < 0.05$). The exposed women worked longer than controls, 12.0 ± 0.0 hours a day (vs. 9.4 ± 1.4 hours; $p < 0.001$). In addition, a higher proportion of control women had either completed the high school or higher level (23.1% vs. 4.3% in exposed women; p

< 0.01). Furthermore, a higher proportion of exposed women had an abnormal auscultation outcome (rales, rhonchi, or wheeze), 32.4%, as compared with control women (vs. 3.5%; $p < 0.01$).

Table 1. Sociodemographic and clinical characteristics of the participants

Sociodemographic and clinical characteristics	Control group (n=256)	Female quarry workers (n=256)	p-value
Age (years); mean (SD)	44.07 (9.41)	43.26 (10.82)	0.380
Working years; mean (SD)	8.35 (7.06)	2.92 (4.55)	**< 0.001**
Daily work duration (hours); mean (SD)	9.41 (1.43)	12 (0.00)	**< 0.001**
Education (%) Primary/secondary (junior high) High school or higher	 197 (76.9) 59 (23.1)	 245 (95.7) 11 (4.3)	**< 0.01**
Smoking status, yes (%)	9 (3.5)	2 (0.8)	**< 0.05**
Lung auscultation, abnormal (%)	9 (3.5)	83 (32.4)	**< 0.01**

Notes: n, sample size; SD, standard deviation; %, percentage.

None of the exposed women used personal protective equipment or mask at workplace. Worksite air monitoring showed significantly higher PM2.5 concentration in stone quarry sites as compared with control sites, 205 μg/m³ (SD: 13.2) vs. 31.3 μg/m³ (SD: 10.3), respectively (p<0.001). Furthermore, stone quarry sites had markedly higher air concentration of VOC, 2.2 μg/m³ (SD: 0.2), compared to control sites (0.5 μg/m³ (SD: 0.3); p<0.01).

3.2. Prevalence of respiratory complaints/disorders and lung function test outcomes

Results of the respiratory health survey showed that respiratory complaints were significantly more prevalent among exposed women than controls: wheezing at rest: 27% vs. 9.1%, respectively (p<0001); wheezing after effort: 22.3% vs. 9.1%, respectively (p<0.05); morning cough: 51.6% vs. 3.2%, respectively (p<0.001); shortness of breath at rest: 31.3% vs. 1.1%, respectively (p<0.001); shortness of breath after effort: 38.7% vs. 0.5%, respectively (p<0.001). Additionally, chronic bronchitis (17.6% vs. 1.1%; p<0.001) and rhinitis (57.8% vs. 13.4%; p<0.001) were common respiratory disorders among stone quarry workers as compared with control group (not shown).

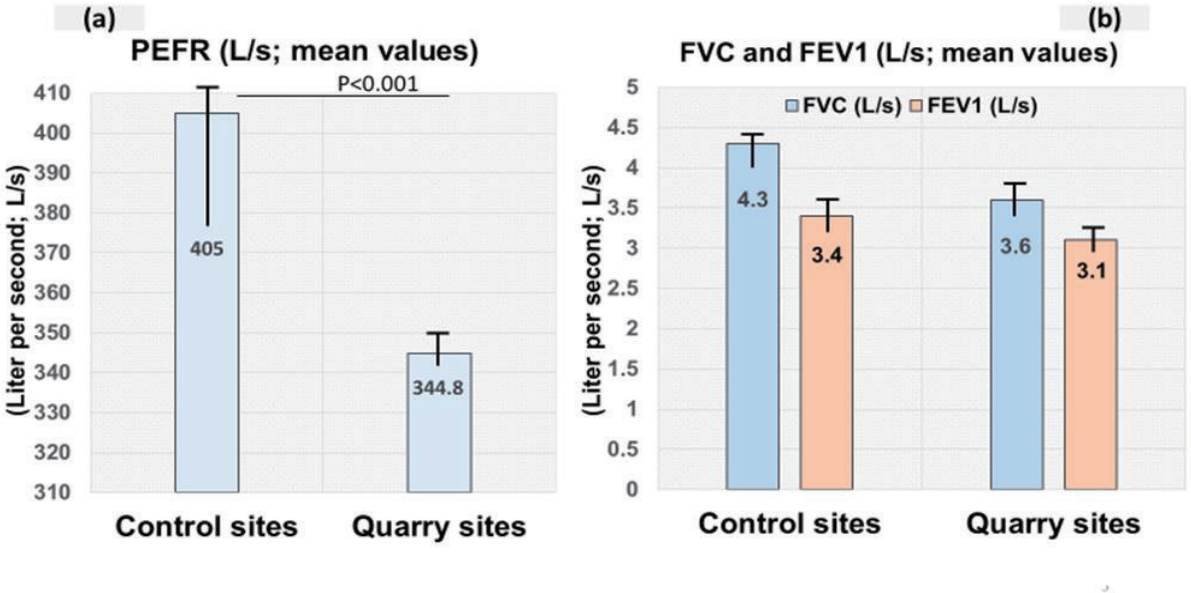


Figure 2. (a) Mean values of peak expiratory flow rate (PEFR) forced vital capacity (FVC) and forced expiratory volume in one second (FEV1); (b) in female stone quarry workers and controls (N=512).

Figure 2 shows the respiratory health profile of the exposed women and controls. It was observed that women working at stone quarry sites had significantly reduced lung performance, particularly in regard to the values of peak expiratory flow rate: 344.8 L/s (SD: 2.26) in exposed women vs. 405 L/s (SD: 67.7) in unexposed office workers and tax collectors (p<0.001). Regarding other lung function parameters such as FVC and FEV1, they were reduced in the exposed women group, but not significantly.

3.3. Association between stone quarry work and respiratory complaints/disorders

When multivariate logistic regression analysis was performed, with adjustment for sociodemographics, most of the respiratory manifestations were associated with quarry work: wheezing/effort (aOR=3.36 ± 1.64; 95%CI: 1.28–8.78; *p*=0.013), morning cough (aOR=6.06 ± 1.88; 95%CI: 3.29–11.15; *p*<0.001), breathlessness at rest (aOR= 3.95 ± 1.15; 95CI%: 2.22–7.02; *p*<0.001), breathlessness/effort (aOR=5.16 ± 1.95; 95%CI: 2.46–10.84; *p*<0.001), morning phlegm (aOR=2.62 ± 0.99; 95CI%: 1.24–5.52; *p*<0.001), chronic bronchitis (aOR=2.61 ± 0.75; CI:95%:1.48–4.61; *p*<0.001), and rhinitis (aOR=2.13 ± 0.21; 95%CI: 1.18–3.39; *p*<0.001) (Table 2).

Table 2. Respiratory complaints/disorders associated with stone quarry work as an occupation in the multi variate logistic regression analysis with adjustment for age, education level and smoking status

Respiratory complaints and disorders	Adjusted OR (SE)	95%CI	p-value
Wheezing at rest	1.09 (0.26)	0.67 – 1.76	0.714
Wheezing after effort	3.36 (1.64)	1.28 – 8.78	**0.013**
Morning cough	6.06 (1.88)	3.29 – 11.15	**< 0.001**
Breathlessness at rest	3.95 (1.15)	2.22 – 7.02	**< 0.001**
Breathlessness after effort	5.16 (1.95)	2.46 – 10.84	**< 0.001**
Morning phlegm	2.62 (0.99)	1.24 – 5.52	**< 0.001**
Asthma	1.21 (0.77)	0.36 – 3.99	0.760
Chronic bronchitis	2.61 (0.75)	1.48 -4.61	**< 0.001**
Rhinitis	2.13 (0.21)	1.18 – 3.39	**< 0.001**

Notes: OR, odds ratio; SE, standard error; CI, confidence interval.

4. Discussion and conclusion

This project is the first that explored the respiratory health of dust-exposed workers in DRC, including female stone quarry workers. It was observed that most female stone quarry workers had very low socioeconomic status and education level; they were exposed to high air pollutants levels, which might contribute to increased prevalence of respiratory complaints and disorders, as well as the observed lung function impairment.

In conclusion, this report highlights the poor air quality in the working environment of stone quarry workers, which expose the workers to high-risk for developing various respiratory disorders.

Author Contributions: Conceptualization, N.L.K. and NRN; methodology, N.R.N., N.L.K. and N.M.K.; software, N.R.N. validation, N.R.N.; formal analysis, N.R.N.; investigation, N.L.K., and N.M.K.; resources, N.L.K.; data curation, N.L.K.; writing—original draft preparation, N.R.N. and N.M.K.; writing—review and editing, N.R.N; visualization, N.L.K.; supervision, N.R.N.; project administration, N.M.K.; funding acquisition, N.L.K. All authors have read and agreed to the published version of the manuscript.

Funding: the study was financially supported by the School of Public Health, Lubumbashi University. Not external fund was received.

Data Availability Statement: Data related to this study can be obtained upon request to the corresponding author.

Acknowledgments: The authors would like to thank the president of the University of Kamina (D.R. Congo), the Director of I.S.T.M. Medical College of Lubumbashi (D.R. Congo), and Mr Imon Sachiyo (I.A.A.P./Kagawa, Japan) for their continuous support to our research project.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. World Health Organization (WHO). Air pollution. https://www.who.int/airpollution/ambient/about/en/
2. UN Environment. Towards a pollution-free planet. https://www.unenvironment.org/resources/report/towards-pollution-free-planet-background-report
3. Nwibo, A.N., Ugwuia, E.I., Nwambeke, N.O., Emelumadu, O.F. and Ogbonnaya, L.U. Pulmonary problems among quarry workers of stone crushing industrial site at Umuoghara, Ebony state, Nigeria. *Int. J. Occup. Environ. Med*. *3*, 178-185 (2012).
4. Isara, A.R., Adam, V.Y., Aigbokhaode, A.Q. and Alenoghena, I.O. Respiratory symptoms and ventilatory functions among quarry workers in Edo state, Nigeria. *Pan Afr. J. Med*, *23*, 212-221 (2016).
5. Taylor, C.D., Schultz, K.J., Doebrich, J.L., Orris, G.J., Denning, P.D. and Kirschbaum, M.J. Geology and nonfuel mineral deposits of Africa and the Middle East, USGS Open-File Report 2005-1294-E. Accessible from: Geology and Nonfuel Mineral Deposits of Africa and the Middle East | U.S. Geological Survey (usgs.gov)
6. Leon-Kabamba, N. et al. Air quality in the working environment and respiratory health of female Congolese stone quarry workers. *Trp. Med. Infect. Dis*. *5*(4), 171 (2020).

Proceedings of
THE 3rd INTERNATIONAL CONFERENCE OF
HYOJEONG ACADEMY 2024

Session 5

Medical and Health Studies

www.lchja.org

What is the ideal Seonghwa?

Toru Hosoda

Hamorebi Clinic, kamagaya, Chiba, Japan
Correspondence: resterupf@yahoo.co.jp

Abstract: The mortality rate of human beings is 100%, some people live more than 100 years, while others die soon after birth. As a terminal care physician in Japan, one of the countries with the longest life expectancy, I am faced with about 70 deaths per year. The circumstances and backgrounds of these people vary, but I always try to realize the best possible end-of-life care. However, it is always difficult to evaluate whether the death was truly good for the patient and the bereaved family. Previous studies have shown that the GDS (Good Death Scale) and GDI (Good Death Inventory) are indices of palliative care, but even in these studies, the evaluation of a good death is not always the same between the medical staff and the bereaved family. This time, we conducted a survey of bereaved families at our hospital, so we will consider what a good death is based on this survey. We will also consider what kind of preparation is appropriate for the second birth.

Keywords: mortality rate, end-of-life care, good death, bereaved families, the second birth

1. Introduction

In a nationwide survey conducted in Japan in November 2020 [1], 58.8% of respondents aged 67 to 81 said they would like to spend the final days of their lives at home (Figure 1). About 40% of respondents said they wanted to avoid their children's homes, followed by nursing homes (Figure 2). Although the number of respondents who said they wanted to stay at home during the final stage of life was somewhat less than previously reported, the majority of respondents still preferred to stay at home, citing the desire to spend time in a familiar place and with family as reasons for this. In recent years, the need for home care has been growing stronger, partly due to the support provided by COVID-19.

In our hospital we also conducted a similar survey, and similarly, many staffs preferred their homes. Some preferred a natural location, such as near the ocean or in a forest.

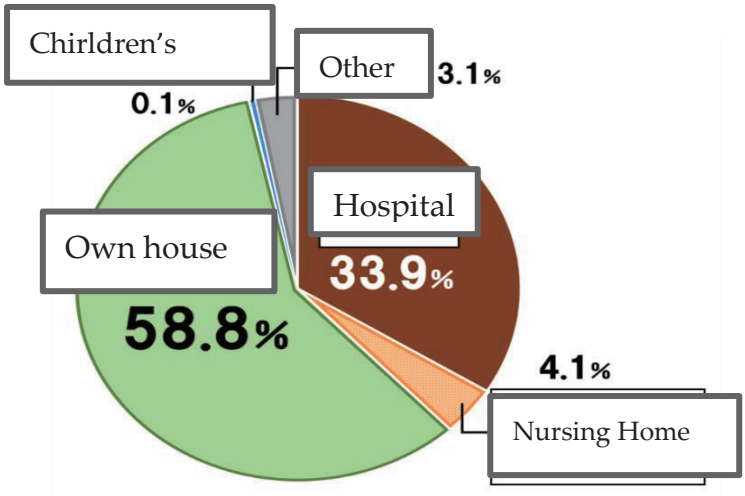


Figure 1. Where you would like to spend the final days of your life "most desirable place."

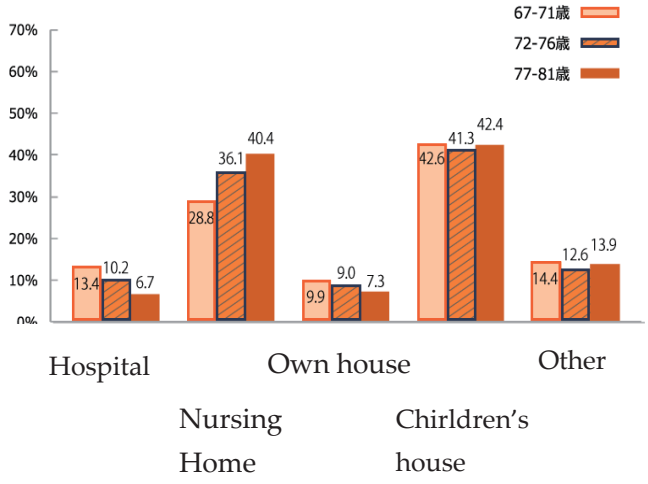


Figure 2. "the place you would most like to avoid."

2. Components of the "Ideal Seonghwa"

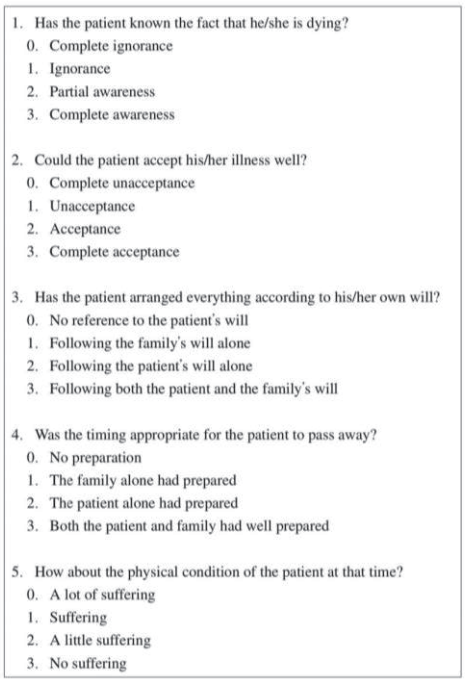
Being in the field of end-of-life care, we experience many deaths. From our experience, we believe that "the patient is not painful," "the family accepts the death," and "we carefully listen to the patient and family words or anxiety" are important components of good end-of-life care, and we practice them. There are also not a small number of deaths, such as the death of a child or a sudden death, that are difficult to accept and cause deep grief to the bereaved family. In such circumstances, the question arises, "What is the ideal end-of-life care, and the ideal Seonghwa? What are the elements that constitute it, and are there any indicators by which we can evaluate it? Next, three previous studies on the components of a "desirable death" are presented.

2.1. Good Death Scale (GDS)

An objective measure of quality of death (QOD) developed in Taiwan, which has been tested for reliability and validity in palliative care units in Taiwan [2].

This study investigated the favorable death status of 366 elderly terminal cancer patients in Taiwan, compared the differences in the degree of favorable death between the older and younger groups, and explored the factors associated with favorable death scores. The following five factors were identified as indicators.

(1) Patients know that their death is approaching.
(2) Patient fully accepts his/her illness
(3) Patient made all preparations according to his/her will
(4) The time of death was appropriate
(5) The patient's physical condition is well controlled.



1. Has the patient known the fact that he/she is dying?
   0. Complete ignorance
   1. Ignorance
   2. Partial awareness
   3. Complete awareness

2. Could the patient accept his/her illness well?
   0. Complete unacceptance
   1. Unacceptance
   2. Acceptance
   3. Complete acceptance

3. Has the patient arranged everything according to his/her own will?
   0. No reference to the patient's will
   1. Following the family's will alone
   2. Following the patient's will alone
   3. Following both the patient and the family's will

4. Was the timing appropriate for the patient to pass away?
   0. No preparation
   1. The family alone had prepared
   2. The patient alone had prepared
   3. Both the patient and family had well prepared

5. How about the physical condition of the patient at that time?
   0. A lot of suffering
   1. Suffering
   2. A little suffering
   3. No suffering

2.2. Good Death Inventory (GDI)

We conducted an interview survey of 63 cancer patients, their families, doctors, and nurses, and extracted elements of quality of life of terminal stage cancer patients in Japan. Furthermore, a nationwide questionnaire survey was conducted, and the following 18 domains were identified as the concept of QOL (concept of desirable death) for Japanese terminal stage cancer patients through quantitative examination.

Core 10 domains

Physical and emotional pain is alleviated.
Spending time in a desired place.
Having hope and enjoyment.
Trusting doctors and nurses.
Not being a burden to family or others.
"To have a good relationship with family and friends."
"To be able to take care of oneself."
To be in a calm environment.
To be cared for as a person.
To feel that one has completed one's life.

Optional 10 Domains

To receive the best treatment possible.
To be able to spend time in a natural way.
To be able to tell people what I want to tell them.
To be able to make my own decisions about my future.
To be able to live without thinking about illness or death.
To not let others see you in a state of weakness.
To be able to feel the value of being alive.
To be supported by faith.

2.3. Good death in Japanese cancer care: a qualitative study

Interviews were conducted to identify the components of a "good death" in the Japanese. Interviews were conducted with 13 patients with advanced cancer, 10 family members, 20 doctors, and 20 nurses.

→ ・The GDS of bereaved family members and physicians did not match.

・Knowing and being prepared for the remaining time" and "being grateful to others and being prepared" were reported as important by more than 50% of the Japanese respondents.

2.4. Opinions of ideal Seonghwa

We also had a free discussion about the components of an ideal Seonghwa. Opinions were expressed from three different perspectives: medical professionals, family members, and patients.

Medical personnel

「Pain control is good.」「Realization of what the patient wants to do」「Breathing is easy」「Sleep at night well」「No edema」

「Not sudden death」「with family at last moment」「being calm」

Family

「The patient does not seem to be in pain」「Can say good-bye, can talk」「Peaceful face」「Sudden death was not painful」

「He was eating his favorite food.」「Being old enough」「Without medical tubes」

Patient

「I want to feel at ease.」「I want to be surrounded by loved ones.」「I want to listen to my favorite music.

「I don't want to be in pain.」「I just want to sleep.」「I want to be touched.」「I don't want to be rubbed by people I can't relate to.」

「I want to be prepared to die.」「I want to have no regrets.」「I want to be able to say thank you.」「 big funeral」「I don't want to be restrained.」「I don't want to have phlegm aspirated」「I want to look beautiful.」 and so on.

3. Discussion

What is the "Ideal Seonghwa"? As a medical practitioner who has learned of the existence of the spiritual world, this is a major theme that we would like to pursue in the future. Both in previous studies and in the discussion conducted at our hospital, multiple elements were indicated, and it was found that they were not one or two, but were composed of a composite of elements. Another important perspective is that the elements seen by "medical personnel" do not coincide with those seen by "bereaved families," which makes this theme even more profound.

Rev. Moon Myung Moon proposed the term Seonghwa and said that the death of the body means the departure to the spirit world and is a second birth. I believe that just as one practices prenatal care for the unborn baby during pregnancy, preparation before going to the spirit world should also be established.

Although not mentioned in the previous study, I believe that the importance of three generations (existence of grandchildren) and the belief that there is an afterlife are also important factors, but this will be tested in the future as hypotheses are formulated.

References

1. *Report on the National Survey on How to Reach the End of Life* (Nippon Foundation, 2021).
2. Cheng S. Y. et al. Good death study of elderly patients with terminal care in Taiwan. *Palliative Medicine 22*, 626-632 (2008).

A Study on Spiritual Healing of the Family Federation for World Peace and Unification: Focused on divine healing cases in HJ Magnolia International Medical Center and HJ Heaven and Earth CheonBo Training Center

Kyubak Lee[1,*] and Insoo Kim[2]

[1]Department of Psychiatry, HJ Magnolia International Medical Center, Gapyeong, Korea
[2]SunHak Universal Peace Graduate University, Gapeyong, Korea
*Correspondence: kyubaklee@naver.com

Abstract: This study explores the potential benefits of combining spiritual healing at the HJ Heaven and Earth CheonBo Training Center, affiliated with the Family Federation for World Peace and Unification (FFWPU), with psychiatric treatment for mental disorders. The research, conducted in collaboration with the Department of Mental Health at HJ Magnolia International Medical Center, emphasizes a case study approach. The study addresses the limited academic research on spiritual healing within FFWPU, focusing on defining it through the teachings of True Parents. Four themes emerge from the discussion: spiritual illness, separation of spirits by Holy Spirit and Truth, restoring mental health through holistic change, and prevention of recurrence. The importance of factors like faith, hope, sincerity, tenacity, repentance, reflection, forgiveness, and appreciation are highlighted, along with the significance of spiritual inheritance and environment in preventing mental health issues. The study concludes by emphasizing the crucial role of a warm family environment and the need to assess spiritual problems in the patient's home or residential area.

Keywords: Spiritual healing, Family Federation for World Peace and Unification, HJ Heaven and Earth CheonBo Training Center, HJ Magnolia International Medical Center, healing case

1. Introduction

In this study, the impact FFWPU's spiritual healing program on mentally ill patients is discussed through case studies. The study is conducted using literature review and case study methods, and based on the understanding of Christian spiritual healing through prior research, the definition and practice of spiritual healing FFWPU are explored. This study is expected to make an important contribution to the field of spiritual healing by suggesting a way that spiritual healing of FFWPU can contribute to mental disease healing.

2. Theoretical Background on Spiritual Healing of FFPWU

First, based on the general understanding of Christian spiritual healing, the theoretical background for spiritual healing of FFWPU is explained. To briefly introduce the definition and characteristics of Christian spiritual healing, it is that “the intervention of God's supernatural power to heal human wounds, pain, and disease, that is, to fight spiritually against Satan and evil spirits through spirit discernment, etc. with the help of the Holy Spirit who came to Jesus Christ. [1] It can be said that it is a process of winning, sharing with Jesus the negative emotions and actions generated through painful memories, practicing the word of truth, imitating Him, and recovering to a healthy state both spiritually and physically [2].” In detail, the Christian spiritual healing is divided into divine healing, inner healing, and healing through spiritual guidance.

FFWPU's spiritual healing centered on divine healing is “to help people suffering from spiritual or physical pain and illness due to the work of Satan and evil spirits through the work of the spirit and truth of the True Parents of Heaven, Earth and Humankind. It can be defined as "the process of separating Satan and evil spirits, achieving holistic growth through the materialization of the Word of Truth, regaining the appearance of a true human being resembling the True Parents of Heaven, Earth and Humankind, and restoring the original healthy spirit self and body.”

The Analytic Frames of FFWPU's Spiritual Healing are described by 3 points of view, that 1) diseases caused by the work of Satan and the evil spirits, 2) separation of spirit due to the work of the Holy Spirit and Truth, 3) Spiritual and physical restoration through materialization of the Word and holistic growth.

3. Case study

Research methods include literature research, in-depth interviews, and case study methods. [2] The subjects of the survey were selected from patients who received spiritual healing at HJ Heaven and Earth CheonBo Training Center and HJ Magnolia International Medical Center (Table 1). The case analysis analyzes the family association's approach to spiritual healing and its effects through several cases in which spiritual healing has been applied.

Table 1. Patient personal information

Pt No	age/sex	Dx	Hospitalization type	marriage
A	10s/F	schizophrenia	outpatient	no
B	60s/F	other psychosis	outpatient	yes
C	20s/F	schizophrenia	agreement	no
D	30s/F	acute psychosis	protection	yes
E	10s/F	schizophrenia	protection	no
F	20s/M	shizoaffective disorder	arbitrary	no
G	20s/F	schizophrenia	agreement	no
H	10s/F	depression	protection	no
I	20s/F	Possession disorder, conversion disorder	arbitrary	no
J	40s/M	alcohol dependence, impulse control disorder	agreement	yes
K	10s/M	Anorexia, adjustment disorder	agreement	no
L	10s/F	Irritable bowel synd	agreement	no
M	20s/M	multiple PD	agreement	no
N	40s/F	depression borderline PD	arbitrary	yes

Several examples describe the changes and healing experiences experienced in the process of spiritual healing. These examples include the development of diseases caused by the action of evil spirits, the separation of spirits through the work of spirits and truth, and the restoration of spirituality through the realization of the words and the growth of the whole person (Table 2). Each case has its own background and problems, and shows

the process of restoring physical, mental, and spiritual health through the spiritual healing approach of family associations.

Table 2. Patient case analysis

Analytic Frames	Disease caused by the work of Satan and evil spirits	Separation of spirit due to the work of the Holy Spirit and Truth	Spiritual and physical restoration through materialization of the Word and holistic growth
A	A/H, being played by spirits, delusions of persecution	Sighting angels and beautiful clouds. Separation of the spirit in the uterus	Improved male phobia, regained her original bright personality, and actively volunteered.
B	A/H telling you to die, sensation of hitting your head	Angel and Absolute Good Spirit, separated by doctor's persuasion	Absolutely believe the word, follow the doctor's instructions spiritual and physical recovery
C	spirit blames his mother, sees evil spirits	Separation of central spirit through the ordination of Daemonim	Studying and practicing the Word, fasting and prayer Recovery from spiritual symptoms
D	spirit Invasion, delirium	work of spiritual healing separation of spirits	study the Words, prayer and sincerity Symptoms of possession disappear
E	Comfort women spirits trying to commit suicide	work of spiritual healing separation of spirits	Becoming one with her mother, overcoming illness and improving relationships with her parents
F	visual and other hallucination	work of spiritual healing separation of spirits	Unity with father
G	A/H, delusions of control, rape victims	work of spiritual healing separation of spirits	Becoming more talkative, brighter, and more proactive

H	Comfort women spirits threatens	work of spiritual healing separation of spirits	Repeated improvement and worsening, requires follow-up
I	sad spirit comes, impulsiveness	Improvement of spiritual symptoms after hospitalization Spirit separation experience	Prayer, sincerity, study of the Word
J	alcoholism violence	After the liberation ceremony, ancestors appear in a dream and offer comfort.	Improvement of suspicious symptoms, restoration of a harmonious family
K	Suicidal thoughts, anorexia	Angels often appear Separation of spirit, improvement in vomiting after convulsions	Prayer, sincerity, and activity recover
L	avoidance of public gas symptoms	liberation of central spirits, separation of resnetment spirits	The original bright personality returns.
M	multiple personality	work of spiritual healing separation of spirits	Prayer, sincerity, study of the Word
N	A/H, V/H	Ancestor liberation, medical angel separation of resentment spirits	Prayer and sincerity, marital conflict and instability

The case study explores how the spiritual healing of family associations contributes to the realization of true family ideals, and how to bring peace and harmony in individual lives and families. Through the analysis of spiritual healing cases, it suggests that the spiritual healing of family associations has the potential to contribute to family, society, and even world peace, not just individual healing.

4. Discussion and Conclusion

The developmental methods of FFWPU's spiritual healing consist of four main themes: spiritual disease and medical diagnosis of mental health, therapist's posture in mental disease treatment and spiritual healing, patient and guardian's posture in mental disease and spiritual healing, and prevention and recurrence prevention. In the first topic, we explore spiritual illness in connection with psychiatric diagnosis. Here, we need to understand the interaction between spiritual problems and mental illness, and find out that spiritual problems are behind many mental illnesses. This emphasizes that accurate diagnosis is the first step in all treatments, and aims to increase awareness and understanding of spiritual problems.

The second topic focuses on the therapist's posture, and the therapist who works on mental illness treatment and spiritual healing must respect and understand the patient's spiritual needs and beliefs. This means considering the patient's spiritual background during the treatment process and applying the principle of spiritual healing to promote the patient's overall recovery. The third topic deals with the posture of patients and guardians. Patients and guardians engaged in mental illness and spiritual healing should actively participate in the

healing process and have an attitude that incorporates spiritual practice into their daily lives. This includes recognizing that spiritual practice can have a positive impact on an individual's recovery process.
Finally, discussions on prevention and recurrence prevention include prevention and recurrence prevention of spiritual inheritance and prevention of recurrence of spiritual environment. This aims to explore strategies and methods for individuals and communities to maintain spiritual health and to prevent recurrence of spiritual problems. These measures are expected to contribute to the development of spiritual healing of the United Nations for the Peaceful Reunification of the World and to provide more effective support to those suffering from mental illness.
Implications and suggestions suggest that spiritual healing can be used as an auxiliary method in the treatment of mental diseases, and the integration of spiritual healing into treatment programs can be beneficial. This can increase the effectiveness of treatment by allowing the patient to pursue both mental and spiritual well-being.
Future research needs to analyze the effects of spiritual healing more closely and explore the applicability of spiritual healing to various types of mental diseases. In addition, research is needed on how spiritual healing can contribute to the management and treatment of physical diseases, especially chronic diseases.
Through an in-depth analysis based on real-world applications of spiritual healing, this study explores ways spiritual healing can contribute to improving mental health and provides evidence to consider it as part of integrated health care.

Acknowledgement: I would like to take this opportunity to thank all those who participated in this study and the professors who commented on the presentation at the International Symposium on 3rd International Conference of Hyojeong Academy.

References

1. Kwon, T. *Christian Spiritual Theology* (Christian Documentary Mission, 2009).
2. Robert, K. *The Case Study Design and Methods* (Sage, 2009).

The Attraction of Nurses Working in a Comprehensive Care System in Japan

Yoko Masumura

Geriatric Health Service Facility Natsumi no Sato, Japan
Correspondence: yokotlove@gmail.com

1. Introduction

Japan's population is aging at a speed unparalleled in other countries. In particular, in 2025, it is predicted that the generation born in the first post-war baby boom will reach the age of 75 or older, resulting in an increase in demand for medical care, nursing care, and social security, and a significant imbalance with demand.

As a countermeasure, the three pillars are enhancement of the community-based comprehensive care system [1], fairness of the review of the burden of public expenses [2], and securing of nursing care personnel [3].

Nurses can play an important role in coordinating and guiding multiple professions as comprehensive health care providers in realizing the "enhancement of the community-based integrated care system."

As a nursing manager at a long-term care facility for the elderly, Natsumi no Sato, a long-term care health facility for the elderly of the Hojukai Medical Corporation, I am working to develop nurses who can instruct and coordinate multiple professions and collaborate beyond the boundaries of the facility.

2. Main Essay

In the midst of the new coronavirus pandemic, the dedication of the nurses is still vivid in people's memories. Personally, I experienced four clusters as a nursing administrator.
We are overcoming the pandemic and returning to our old lives.

Japan is now facing a super-aging society that it has never experienced before. This is due to an increase in the elderly population, a decrease in the population, and a decrease in the working generation. In FY2022, the aging rate reached 29.0%, and the proportion of the working generation that supports them has decreased to 59.4%.

The current situation is that two people of the working generation support one elderly person. The proportion of the elderly will continue to rise, and the proportion of the working generation will continue to decline, and a society in which 1.3 people in the working generation support one elderly person is about to arrive.

Japan is promoting the "enhancement of the community-based comprehensive care system" from a hospital-based system to a community-based system. What is the "Community Integrated Care System"? It is a system that provides housing, medical care, nursing care, prevention, and life support in an integrated manner so that even if a person becomes severely in need of long-term care due to a decline in physical function or cognitive function, he or she can continue to live in his or her own way in the community where he or she is accustomed to living until the end of his or her life.

Healthcare providers are encouraging early discharge from the hospital once acute treatment has been administered. As a result, elderly people whose physical and cognitive functions have declined due to hospitalization are often unable to return to their original places of living immediately. In addition, long-term care facilities that can be entered at public expense are required to have stable physical and cognitive functions.

Under such circumstances, the elderly health center where I work has specialists such as doctors, pharmacists, nurses, rehabilitation staff, caregivers, registered dietitians, nursing care support specialists, and support counselors, and it is possible to accept elderly people who have just completed treatment at the hospital. In addition, as an intermediate facility between hospitals and homes, it supports the elderly to live in a familiar place through multidisciplinary collaboration and home support through return to home.

In Japan, where nuclear families have progressed, there are many cases where elderly people care for the elderly and people with dementia care for people with dementia, making it difficult to detect abnormalities in the elderly at an early stage in daily life.

In outpatient rehabilitation, elderly people living at home are provided with rehabilitation, bathing, meals, and recreation during the day. In this context, it is possible to detect changes in the physical and psychological aspects of the user, collaborate with the family and care manager, provide necessary medical care and services to the user and family, and detect and respond to abnormalities at an early stage.

For example, by finding bruises when bathing, you may notice that a family member is tired of caring for you and has been violent, or that there is a discrepancy between the progression of the person's illness and the living environment. In such cases, we review the future direction of the facility while providing medical care and rehabilitation to the person and time to rest for the family. In some cases, it is difficult for the family to treat pressure ulcers made at home, and patients who do not improve are admitted to the facility, and the nurse treats them and improves them before returning them home.

In addition, by entering the old age, the doctor can also adjust the medication. Recently, elderly people living alone were required to inject insulin once a day, but because they could not self-inject, there were cases where family members living in different houses had to go for injections every day. Due to his family's work, he was admitted to an institution because he could not inject insulin. During that period, I was able to change my blood sugar control from injections to oral medications, which was appreciated by my family because I was able to reduce the burden on my family.

Recently, the elderly health center also provides terminal care, and it is a facility with various possibilities. Prior to the introduction of terminal care, it was judged that it would be difficult to continue to see elderly people whose condition had deteriorated in a facility, so they were transported to hospitals. In the midst of all this, one man said, "Please, don't send me to the hospital, I want to die here." He cried and appealed to me. At that time, the facility did not have a system for taking care of the man, so he could not fulfill the man's wishes. However, he has now made it possible to fulfill that wish and realize the life of the elderly in the community to live their own lives until the end.

"You are there and I am, and people shine when they are there for the other person. We aim to be useful to society." In accordance with our corporate philosophy, we provide medical and nursing care on a daily basis while respecting others and valuing our gratitude.

3. Conclusion

In the community-based comprehensive care system, elderly people play a variety of roles in order to realize that the elderly in the community can live their own lives until the end. It can be established through multidisciplinary collaboration and multidisciplinary collaboration that transcends the boundaries of facilities, not only in facilities but also in hospitals, nursing homes, and homes, focusing on the elderly. Among them, nurses are in a position to coordinate and guide multiple professions as comprehensive medical care providers. Ibe et al. say that "the quality of nursing care is also greatly related to the quality of life of local residents"[1]. What we need to do as nursing managers is to guide and coordinate multiple professions, and to train nurses who can collaborate across the boundaries of facilities to overcome the super-aging society.

References

1. Toshiko Ibe, et al. Healthcare System Theory 2023 Edition, Nursing Management Learning Textbook 3rd Edition, Japan Nursing Association Press
2. Toshiko Ibe, et al. 2023 edition of the theory of management resource management, Nursing management study textbook 3rd edition, Japan Nursing Association Press
3. Toshiko Ibe, et al. Organizational Management Theory 2023 Edition, Nursing Management Study Textbook 3rd Edition, Japan Nursing Association Press

Acupuncture Treatments for Allergic Rhinitis

Shawheen Alavi-Moghaddam and Sanghyun Lee*

Wongu University of Oriental Medicine, Las Vegas, NV 89123, USA
*Correspondence: sanglee@wongu.edu

Abstract: Many research studies have shown acupuncture to be effective in treating allergic rhinitis. The acupuncture points that are classically used for the symptoms of allergic rhinitis, were shown to be more effective than a general acupuncture treatment. Acupuncture has been shown to regulate levels of IgE and cytokines, to improve symptoms. Other ways of measuring the effect, include the Rhinitis Quality of Life Questionnaire, and the Total Nasal Symptom Score. Studies have found that acupuncture is more effective than western style medication, for the treatment of allergic rhinitis. Acupressure and moxibustion have also been shown to be effective. Acupuncture can influence biochemical pathways that are relevant to allergic rhinitis. Acupuncture has the effect of down-regulating proinflammatory neuropeptides and neurotrophins. Additionally, acupuncture down-regulates Th2 cytokines and proinflammatory cytokines, thus shifting the Th1/Th2 balance of T helper cells towards Th1. Electroacupuncture has the added benefit of targeting certain neuropeptides, according to the electric frequency used. In an inflammatory pain model, acupuncture influences adenosine in the body to act on A1 receptors, to produce antinociceptive effects of acupuncture. TRPV1 expression is inhibited by acupuncture, through downregulation of production and release of NGF and/or by blocking PI3K/PIP3 signaling between trkA receptors and TRPV1. Adenosine release from acupuncture also inhibits TRPV1.

Keywords: Allergic Rhinitis, Acupuncture, Moxibustion, IgE, Adenosine, TRPV1

1. Introduction

Allergic rhinitis is a chronic or seasonal illness, characterized by inflammation, sneezing, nasal discharge. The condition has a marked effect on quality of life, in addition to having uncomfortable symptoms. For some people, Western style medication may be sufficient. Other patients might benefit from pharmaceuticals plus acupuncture, to fully address symptoms. Some patients with severe conditions, do not get much benefit from Western drugs, so acupuncture will provide a novel opportunity to treat the illness.

2. Materials and Methods

Research was conducted by intenet web search. Relevant research articles were found on various databases, such as PubMed. The research for this paper is limited to articles written in English.

3. Results

In Chinese Medicine theory, allergic rhinitis is categorized as Bi Qiu. The Zang-Fu organs of kidney, spleen, and lung, may be affected by deficiency, excess, heat, or cold, thus resulting in allergic rhinitis [1].

Allergic rhinitis is induced through immunoglobulin E (IgE), in response to allergens in the air. Inflammation of the nasal membranes, will show symptoms such as nasal congestion, sneezing, itchiness, and nasal discharge [2]. Allergic rhinitis negatively affects quality of life. In the USA, 60 million people suffer from the disease, annually. Western treatments for allergic rhinitis include antihistamines, glucocorticoids, and bronchodilators [2].

Examples of acupuncture points used for allergic rhinitis include, XinWu (sphenopalatine ganglion), YinTang, Large Intestine 20, Urinary Bladder 13, Du 14, and Large Intestine 4, among others [2]. Treatment durations may range from 1 to 2 months. Adding moxibustion to the acupuncture treatment, is shown to increase the effectiveness of the acupuncture treatment, by providing the most benefit to IgE levels [2]. Acupuncture is shown to be more effective, than conventional Western medicine, for treating symptoms of allergic rhinitis.

Acupuncture has been used for thousands of years, to treat allergic rhinitis, with established techniques. Research into the biochemical effect of acupuncture on allergic rhinitis, involves studying downregulation of pro-

inflammatory neuropeptides, cytokines, and neurotrophins [3]. These have a relationship with the Gprotein coupled receptor, transient receptor potential vallinoid (TRPV1) [3]. Other research focuses on the cholinergic anti-inflammatory pathways. During acupuncture, acetylcholine released from the vagus nerve, can inhibit proinflammatory cytokines, by binding to α7-nicotinic receptors [3]. The balance of Th1/Th2 cytokines, can be pushed away from Th2 dominance, with acupuncture treating allergic rhinitis [3].

Vagus nerve stimulation along this pathway involves both sympathetic and parasympathetic functions [3]. Dopamine receptors will act in a selective manner during the acupuncture. D1 receptors, found in the brain, will inhibit analgesic effects. D2 receptors in the spine, will boost analgesic effects [3].

Inflammatory pain can be moderated by adenosine A1 receptors. Adenosine triphosphate (ATP) is released in the tissue during acupuncture, and then metabolizes into adenosine, which will then act on the adenosine A1 receptors, to reduce inflammation [3]. Desensitization of chemokine receptors, can contribute to adenosine-induced downregulation TRPV1, which will benefit symptoms of allergic rhinitis [3].

Conventional western treatment for allergic rhinitis, mainly involves the use of antihistamines and intranasal topical glucocorticoids. Long-term use of glucocorticoids, leads to side effects, such as nasal dryness, and bloody nose [4]. For some patients with moderate to severe allergic rhinitis, the drug treatment fails to be effective [4]. So, naturally acupuncture provides a different strategy for potentially effective treatment, with no severe adverse effects.

In 2017, a study in Germany, researched acupuncture for seasonal allergic rhinitis [5]. The participants of the study, either received acupuncture, or were placed into one of the control groups. It was an 8 week long study. As pollen season reached its peak, during the study, the patients in the control groups increased their use of antihistamines to address symptoms [5]. Whereas, the acupuncture patients did not increase antihistamine use during peak pollen levels. Acupuncture points used include Large Intestine 4, Large Intestine 11, Large Intestine 20, and YinTang. At least three out of eight of the following points were also used during each treatment session: Urinary Bladder 13, San Jiao 17, Spleen 6, Stomach 36, Lung 7, Liver 3, Gallbladder 20, and BiTong [5]. The antihistamine used during this study was Cetirizine. 38% of acupuncture patients in this study did not use any antihistamines. 16% of control group patients did not use any antihistamines [5]. The study showed favorable results for acupuncture.

A study on Ear Acupressure, has shown benefits for allergic rhinitis treatment [6]. Points used on the ear were ShenMen (TF4), Internal Nose (TG4), Lung (CO14), Wind Stream (SF1,2i), and Adrenal Gland (TG2p). Stainless steel pellets were taped to the points. Patients were advised to press the pellets on the acupressure points, for about 10 seconds, three times a day [6]. Pellets were removed by the acupuncturist after one week, and then the opposite ear was given a new set of acupressure pellets for the coming week. This study used only acupressure, with no skin penetration [6].

4. Discussion

Acupuncture regarding allergic rhinitis, has ample research to show its safety and effectiveness. Improving this evidence would involve further clinical trials with larger sample sizes. The points that are traditionally used for acupuncture, can be shown to have positive effects on biochemical pathways involving the immune system. Moxibustion provides added benefit for relief of symptoms. The conclusion is that acupuncture is a useful strategy for treatment of allergic rhinitis, especially if symptoms are not properly addressed by Western pharmaceuticals. As acupuncture becomes more popular in the future, we may see the rates of allergic rhinitis decreasing.

Authors contribution: Shawheen Alavi-Moghaddam performed research for the paper, and wrote the text of the paper. Dr. Sanghyun Lee provided support, mentoring, and guidance, for this research.

Funding: This research received no external funding.

Data Availability Statement: Data supporting these results can be found in medical research journals, such as the ones listed in the references below.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Yang, J. et al. The effectiveness and safety of acupuncture for allergic rhinitis: Protocol for an overview of systematic reviews and meta-analyses. *Medicine 99*(29), e21225 (2020). doi: 10.1097/MD.0000000000021225. PMID: 32702893; PMCID: PMC7373564.

2. Yin, Z., Geng, G., Xu, G. et al. Acupuncture methods for allergic rhinitis: a systematic review and bayesian meta-analysis of randomized controlled trials. *Chin Med 15*, 109 (2020). https://doi.org/10.1186/s13020-020-00389-9
3. Jing, X. et al. Mediators, receptors, and signalling pathways in the anti-inflammatory and antihyperalgesic effects of acupuncture. *Evidence-Based Complementary and Alternative Medicine* (2015). https://doi.org/10.1155/2015/975632
4. Bao, H. et al. Damchaaperenlei D, Li C, Yu M, Li Y. Acupuncture for the treatment of allergic rhinitis: A systematic review protocol. *Medicine 97*(51), e13772 (2018). doi: 10.1097/MD.0000000000013772. PMID: 30572530; PMCID: PMC6320097.
5. Adam, D. et al. Impact of acupuncture on antihistamine use in patients suffering seasonal allergic rhinitis: secondary analysis of results from a randomised controlled trial. *Acupunct Med.36*(3), 139-145 (2018). doi: 10.1136/acupmed-2017-011382. Epub 2018 Feb 10. PMID: 29440045; PMCID: PMC6029641.
6. Ding, X., Huang, S., Tang, Y. and Lin, J. Effectiveness and safety of ear acupuncture for allergic rhinitis: A protocol of randomized controlled trial. *Medicine* 100(12), e24943 (2021).

A Study on the Integration of Oriental Medicine and Western Medicine: Oriental Medicine diagnoses with spiritual sensitivity also treat the spiritual human body

Shu Miyahara

Gengido Miyahara acupuncture treatment center, 2-63-14 Kotake Nerima-city Tokyo, Japan
*Correspondence: miyahara@dr-shu.com

Abstract: Oriental medicine treats not only the patient's physical body but also the spiritual body. This is a major difference from Western medicine. There are also differing views on the nature of the mind. In Oriental medicine, not only the brain but also each internal organ is considered to have a unique mind. The aim of this paper is to examine these differences and stand at the threshold of unified medicine.

Keywords: Unified Medicine, Spiritual Sensibility

1. Introduction

Eastern medicine and Western medicine are trying to move on the path to unified medicine.

Oriental medicine actively incorporates the knowledge of Western medicine to improve the therapeutic effect. Knowledge of anatomy, physiology, and pathology has helped to provide more detailed, accurate, and safe treatments. The method is shown in 2.1.

Western medicine, on the other hand, has an increasing number of treatment methods, such as replacing scalpels with acupuncture and replacing medicines with herbal medicines. There are also more options for patients. There may also be more diseases that can be cured. However, this is only the introduction of the tools of Oriental medicine into modern medicine. The essence of oriental medicine has not been introduced.

The essence of Eastern medicine that differs from Western medicine is that it considers human beings as spiritual beings as well as physical beings. In other words, human beings have a dual structure of spiritual and physical bodies. And acupuncture stimulates the spiritual body at the same time as inserting acupuncture needles into the body. The spiritual stimulus is then transmitted through the meridians, which are the spiritual vascular system, and has an effect on the affected area.

It is hoped that Western medicine will diagnose human beings as spiritual beings in this way and treat them with spiritual influences in mind. However, spiritual beings themselves cannot be ascertained by existing measuring instruments, and therefore their existence cannot be recognized. Diagnostics will be highly mechanized, and only the data that comes out of the measuring instruments will be treated as the truth, and anything that is not will be non-existent. It is expected that measuring instruments that can detect spiritual beings will appear. Or, as in the case of Oriental medicine, spiritual sensitivity can be incorporated into the diagnosis. Examples of diagnostic methods in Oriental medicine using spiritual sensibility are shown in 2.2.

Another major difference between Eastern medicine and Western medicine is the way the mind and body are perceived. The patient's mind has a great influence on the state of the body. In Oriental medicine, we believe that each internal organ is responsible for its own unique emotions, as shown in Table 1. That's why we place importance on the patient's mind and use it for diagnosis and treatment. An example of this treatment is 2.3.

The mind and body are the internal nature and external shape of one individual. These are similar. Similarly, if the internal properties and external shapes of each organ are similar, we can imagine the internal properties from the external shapes [1]. In other words, psychological effects can be imagined from the shape and physiological effects of organs. Since each organ is in the body, the function of each organ is not individually recognized. The internal organs are responsible for each of the body's physiological functions as a whole. Similarly, the mind has a variety of emotions, but it is difficult to know where they are coming from. The whole feels like one mind, but the internal organs are thought to be responsible for each. This hypothesis was shown in the results.

2. Methods of Oriental Medicine

2.1. How Eastern Medicine Incorporates Western Medicine Knowledge

(1) Perform qigong treatment on patients with sinusitis while looking at the anatomical diagram around the sinuses. Using the structural knowledge of the sinuses, it is possible to perform qigong more finely and accurately.
(2) Treat patients with uterine fibroids with reference to abdominal imaging and doctor's explanations. Information such as the condition, size, approximate location, and number of fibroids is helpful.
(3) For patients with foot pain, treatment of the foot did not heal. The position of the abdominal aorta toward the foot is grasped by the anatomical diagram, and qigong and acupuncture are used to concentrate qi there.
(4) For patients who feel tired of the head, perform qigong diagnosis using knowledge of brain anatomy and cerebral physiology. By referring to the anatomical diagram and injecting qi into the details, you can remove the extra qi as if you were cleaning the details.
(5) By referring to data such as blood tests and blood pressure, it is possible to know whether the treatment is deteriorating or improving.
(6) The condition of gallstones can be known by diagnostic imaging of gallstones. This will lead to a course of treatment.

2.2. Oriental Medicine Diagnostic Methods Using Spiritual Sensibility

(1) Value the first impression of the patient.
(2) Instantaneously capture the impression of touching the body.
(3) Pulse examination examines the pulse of the arteries in the left and right wrists. Two skilled acupuncturists may diagnose different diagnoses when they examine the pulse of the same patient. This means that the results will vary depending on the person who examines the pulse, and the spiritual influence cannot be ignored.
(4) Put a spiritual hand in the patient's body to find out what is wrong.
(5) Explore whether there are any places around the patient's body that feel different from the usual space.
(6) Investigate the patient's face, eyes, body surface, and clothes to see if there is any unnaturalness.
(7) Investigate whether there is anything unnatural in the patient's voice, smell, gestures, etc.

2.3. How Oriental Medicine Uses the Relationship Between the Mind and Internal Organs to Treat

(1) The liver is the organ responsible for sharing anger. People who have a lot of anger have stiff flanks, which are the reaction points of the liver. Acupuncture here relieves shoulder stiffness, but it can also relieve anger.
(2) The heart is an organ that shares pleasure. People who have little emotional expression and little joy may feel pain when they touch the area near the pulpit, which is the reaction point of the heart.
(3) The stomach is an organ that shares thoughts and sorrows. In order to think quietly and think deeply, it is necessary to have a stable stomach qi.
(4) The lungs are the organs responsible for sharing grief. How to become a person who can feel the pain of others
(5) The kidneys are the organs that share fear.

3. Results

3.1. Psychological effects of each organ derived from the relationship between mind and body

3.1.1. Liver

The liver can store blood and release it as needed. Considering this, the effect of emitting anger is in the liver. The liver is responsible not only for anger, but also for the determination to start something and the upward emotion of taking the first step.

3.1.2. Heart

The heart constantly delivers nutrients and oxygen throughout the body through the blood. Considering this, it plays a role in delivering love and vitality to the whole body. It is like the heart of a God who loves mankind without ceasing, and it is full of joy.

3.1.3. Stomach

The stomach is responsible for the digestion of food. What can be considered from this is the digestion of thoughts. In our social lives, we are bombarded with many thoughts from others. It is the stomach that digests these.

3.1.4. Lungs

The lungs take in oxygen contained in the air as they breathe. At that time, the air from the outside is temporarily accepted into the body. What you can think of from this is to take the other person's feelings and grasp them emotionally. It works to read the atmosphere around you. He is also in charge of emotional responses such as sadness.

3.1.5. Kidneys

The kidneys take waste products out of the blood to make raw urine and return the necessary water to the blood. It works to regulate blood components and maintain homeostasis. What can be considered from this is the maintenance of psychological homeostasis. Work like a conscience. When you are about to do something wrong, your conscience kicks in and puts a stop to it and pulls you back to its normal position. It is the kidneys that feel the pangs of conscience and fear.

Table 1. The relationship between the five organs and the mind

Five organs	mind
Liver	Anger
Heart	Joy
Spleen	Melancholy
Lungs	Sadness
kidney	fear

4. Discussion

As mentioned in 2.1, Eastern medicine benefits from the test results and knowledge of Western medicine. It can be treated without it, but if there is information from Western medicine, it is actively incorporated. However, there are many things that I wish could be treated in an integrated manner with Western medicine. For example, the example shown in 2.1 is as follows.

(1) For patients with sinusitis, if it is possible to use images of the patient's sinus area instead of the anatomical diagram of the sinus area, it is possible to perform qigong more finely and accurately. It would be even better if I could watch the video in real time while being treated.

(2) Even in patients with uterine fibroids, the shape, size, and position of multiple fibroids change depending on the stimulation of treatment. It would be very helpful if we could grasp this situation more accurately in the video.

(3) If we could treat a patient with leg pain more accurately by looking at the image of the abdominal aorta, it would be more reliable than relying on spiritual sensitivity to search the abdominal cavity.

(4) Qigong treatment for patients who feel tired of the head can only confirm whether or not the results have been achieved by the patient's own subjectivity and the spiritual sensitivity of the practitioner. It would be very good if this could be easily confirmed with an electroencephalograph or a device that measures blood flow in the brain.

These things may be possible with adequate diagnostic equipment and cooperation with specialized physicians for patients.

On the other hand, the answer to the question of whether Western medicine benefits from Eastern medicine is infinitely negative. The purpose of this paper will be achieved if the following points can be incorporated into the diagnosis and treatment of Western medicine.

(1) Refer to the spiritual sensibility shown in 2.2 in the diagnosis.

(2) Diagnose the mind and body in a unified manner. I would like you to examine me from the perspective shown in 3.1.

(3) I would like you to incorporate the methods of oriental medicine in your treatment and make use of your way of thinking and philosophy.

References

1. Holy Spirit Association for the Unification of World Christianity, *Divine Principle,*2nd ed. (Kogensha, 1995).

Research on a Whole Person Health Model Integrating Unification Thought and Ken Wilber's Integrative Healthcare System

Hyunmin Ryu

Oxygen Footprint Co., Daejeon, Korea
ryu-topia@hanmail.net

Abstract: This research focuses on developing a whole person health model that combines Unification Thought and Ken Wilber's integrative healthcare system. Given the importance of physical, mental, and spiritual health in modern society, this research emphasizes the unification of body and mind, the integration of Eastern and Western medicine, and the importance of exercise, diet, prayer, and meditation in daily life. The purpose of the study is to develop a new multidimensional approach to health through the convergence of Unification Thought and Ken Wilber's system and to provide a new perspective on the understanding and practice of health. The results of the study show that the fusion model integrally promotes physical, mental, and spiritual health and has the potential to positively impact overall well-being. The model provides a new understanding of health and offers healthcare professionals a new way to manage the overall health of their patients.

Keywords: unification thought, ken wilber, holistic health, health model, integrative healthcare, whole person health

1. Introduction

Modern society increasingly recognizes the importance of physical, mental, and spiritual health. This study explores the need for a whole-person health model that combines Unification Thought and Ken Wilber's integrative medicine system. Unification Thought emphasizes the unification of the body and mind, centered on true love, and the integration of Eastern and Western medicine, while Ken Wilber's system of integrative medicine views the health of the body, mind, and spirit as a continuum and emphasizes balance. The purpose of this research is to develop a new multidimensional approach to health by fusing these two schools of thought. This approach includes the unification of body and mind, the integration of Eastern and Western medicine, and the importance of exercise, diet, prayer, and meditation in daily life. The research question focuses on "How can we effectively fuse Unification thought with Ken Wilber's system of integrative medicine, and what new perspectives can this fusion provide for our understanding and practice of health?"

This research is expected to bring a new multidimensional approach to health to the health field, which can contribute to promoting overall health and well-being. By providing a new understanding and practice of health, it will also provide professionals in the field with practical guidelines on how to effectively address the complex needs of patients.

2. Theoretical Background

2.1. Health in Unification Thought

In Unification thought, health comes from the unification of body and mind [1]. The visible body and the invisible mind must be united to be healthy [2]. According to the Divine Principle, the mind and body are in a relationship of dual characteristics. The mind is the internal nature and the body is the external form, and they are interdependent. The physical self is the dual characteristics of the physical mind and the physical body, and the spirit self is the dual characteristics of the spirit body and the spirit mind. In addition, the spirit self receives vitality element from the physical self to grow, and returns living spirit element to the physical self [3].

By receiving life elements from God and vitality element from the physical self, the spirit self has access to the divine beyond the self, from which it derives vitality and joy. As a result, the spiritual self returns living spirit element to the physical self to promote the health and vitality of the physical body. In other words, the health of the spiritual self is affected by what vitality element it receives from the physical self, and the health of the physical self is affected by what living spirit element the spiritual self receives from the physical body [3]. On the other

hand, human suffering and unhappiness is due to the lack of a smooth give and take action between the physical and spiritual self. The failure to live by human nature and conscience and to be drawn to instincts and pleasures that come from selfishness are the causes of human suffering [4].

Unification Thought emphasizes that it is God's ideal to fulfill the three great blessings of Genesis 1:28, which are nourishment, reproduction, and to rule over the universe. Humans have been given the authority to rule over all things instead of God, and the body and mind must become one through self-domination, where the mind rules over the body. However, when the body, which is supposed to be under the control of the mind, is instead under the control of the mind, suffering ensues. This is why Rev. Sun Myung Moon emphasized, "Complete self-dominion before seeking universal dominion!" [5]. Just as God created creation, ruled it with his heart, and ruled it with love, it was believed that it was possible for humans to perfect their ruling nature when they began to resemble God's ruling nature.

Therefore, the first condition for liberating ourselves from suffering through the unification of body and mind is to restore God's heart. The heart is the "impulse of joy and love" that comes from the deepest part of the human being [6]. When the heart is developed, the sinful nature is extinguished, the mind is purified, and the impulse of joy and love is triggered, resulting in the healing of the mind and body. The impulses of joy and love triggered by the mind and body promote the unity and health of the human mind and body."[4].

In short, true love, which is generated from the heart, is a core value of Unification Thought. Resonance of body and mind is also possible in true love [7]. True love is the love that gives and forgets, that gives and forgets [8]. In love, there should be no selfishness or desire [9]. The more we love, the younger our inner man, the spirit self, becomes [10]. Unificationism emphasizes that health and happiness come from loving and serving humanity, not self-centeredness. Pure love for an object creates a resonance that harmonizes with the frequency of the object and unites them. Through resonance, love is amplified, meaning that the object of love is comprehensive and integral, from human beings to all of creation, from the individual to the family, society, race, nation, and world. Health is not merely at the individual level, but is possible when health is improved and restored in all areas of human connection, with true love at the center. This is because the human body is a microcosm [11] and a microcosm [12] of the universe, with a corresponding relationship with the nature of the Creator.

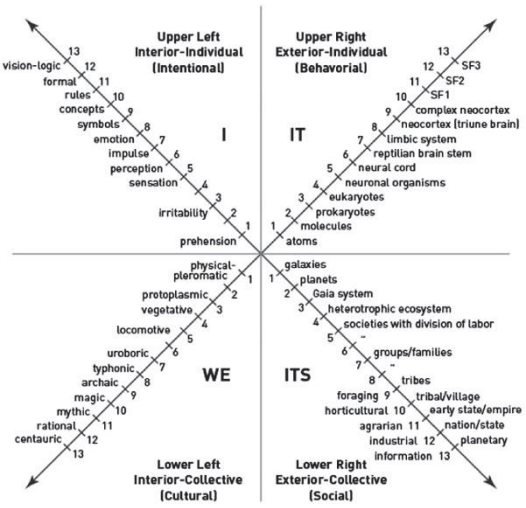
Therefore, according to Unification Thought, for the sake of our health, we must love all of creation that is connected to us. On Earth, the love of God's creation surrounds us on all sides, so we should be grateful for the fruits of love [13], love the sunlight, love the earth, love the water and air [14], because all beings have the same heart [15].

In the same vein, the methods for personal health are also centered on true love. If you also have a loving heart, you will not get sick, so you should also practice moral discipline [16]. For example, Reverend Sun Myung Moon taught the True Love Diet, saying that when you eat with true love, all things are abundant, there is harmony in all of heaven and earth, and you can live without illness until you die [17]. He also maintained his health through daily exercise and breathing exercises, saying that when he woke up, he exercised all five fingers from the little finger up [18], and stretched his shoulders, neck, and back [19], and started the day with a breathing exercise he developed [20]. He also recommended meditation, which is a time of enjoyment and friendship with the mind [5], and emphasized that if one is diligent in fasting and praying, the mind can control the body [21], and with this mental strength, one can stay healthy and overcome any difficulties [22], so that one can be tired but not controlled by tiredness, [26] that one should think of oneself as a healthy person who does not need medication [24], and that if one is sick, it is only to become healthier [25] that the sickness will come and go and one will become healthier.

The Unificationist concept of health emphasizes holistic well-being through the integration of body and spirit. To this end, it emphasizes that health and happiness are amplified when love extends beyond the individual to the whole of humanity and all creation. This suggests that humans are part of nature and the universe, in a corresponding relationship with the nature of the Creator. Therefore, maintaining good health requires disciplines such as proper exercise and breathing techniques centered on true love, and meditation and fasting prayers to cultivate mental strength. These methods provide a way to harmonize the body and mind, and to improve outer health through inner peace.

2.2. Ken Wilber's Integrated Healthcare System

Wilber's thought describes the holistic universe as a dynamically evolving process, driven by the Absolute Spirit, and the human consciousness of the various tides developing on different wavelengths, in a fully integrated model of hot, cold, and holistic [26]. In this context, Ken Wilber's system of integrative medicine is part of his broader theory of integration, an approach to healthcare based on an understanding of the multidimensional nature of human existence. Wilber presents a concept of the "whole person" that encompasses physical, mental, social, and spiritual dimensions, and emphasizes the ways in which these various dimensions interact and influence each other. Based on a critical reflection on conventional medical approaches, Wilber's system emphasizes a holistic approach that takes into account the mental and spiritual aspects of the human being, rather than treating only the physical ailments. It aims to address underlying causes and improve an individual's overall health and well-being, rather than simply relieving symptoms. It also incorporates the best of both Eastern and Western medicine and includes a variety of therapies and practices to address a person's health in a multidimensional way. Wilber's system of integrative medicine can be seen as an attempt to bridge the gap between conventional and complementary medicine and provide a more comprehensive and personalized approach to treatment.



(a)

Alternative Medicine	**Conventional Medicine**
Emotions Psychological attitudes Imagination Intentions	Surgery Pain medication Medications Behavioral restrictions
I	It
WE	Its
Cultural Perspectives	**Social Systems**
Cultural values Cultural judgment Meaning of illness Groups that support patients	Economic Factors Insurance Health care policy Social delivery systems

(b)

Figure 1. (a) Kenwilber's AQAL; (b) The four quadrants of integrated healthcare [5].

Figure 1. is a schematic representation of integrative healthcare, based on Ken Wilber's quadrants. This pattern is called AQAL, which is a shorthand for All Quadrants, All Levels, All Lines, All States, All Types [27]. Wilber proposes that each of these quadrants represents a different aspect of reality and that they are all interconnected. For example, an individual's health is not only a matter of biology (external to the individual), but is also influenced by individual psychology (internal to the individual), cultural beliefs and values (internal to the group), and social structures such as healthcare systems (external to the group). Ken Wilber's integrative healthcare model argues that in applying an integrative approach to healthcare, we need to consider the whole quadrant, rather than the conventional modern medical approach of the idol quadrant. While the right quadrant deals with disease primarily through physical interventions such as surgery, medication, and behavioral restrictions, the integrative model emphasizes that the inner state of the individual in the left quadrant is an important cause of disease and has a major impact on treatment. This suggests how the individual's consciousness interacts with the intersubjective elements of the lower left quadrant, which are intertwined with cultural values, beliefs, and worldviews. In the lower right quadrant, social systems, economic factors, and insurance systems play an important role in the social context of disease and access to care. This means, for example, that failures in

the distribution of food or the delivery of drugs and therapies can have a direct impact on morbidity and mortality. By providing holistic care that encompasses the physical, emotional, mental, and spiritual levels, Ken Wilber's integrated model addresses the multifaceted causes of disease and improves quality of care while reducing healthcare costs. By adding levels to each quadrant, the model seeks a comprehensive and effective approach to healthcare that promotes the overall health and well-being of patients.

2.3. Access to Health in Major Healthcare Organizations

2.3.1.Concepts of health at the World Health Organization and the U.S. National Center for Complementary and Integrative Health

The World Health Organization (WHO) defines health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." [28]. It is one of the fundamental rights that all human beings should enjoy, regardless of race, religion, political belief, economic or social situation, and includes the enjoyment of the highest attainable standard of health. The WHO also explains that health is influenced by a person's situation and environment. This includes where you live, environmental conditions, genetics, income and education levels, and relationships with friends and family, all of which have a significant impact on your health. Similar to the factors considered in public health activities, access to and use of health services also have a significant impact on health, the organization emphasizes.

The U.S. National Center for Complementary and Integrative Health (NCCIH) distinguishes between complementary and alternative medicine, integrative health, and whole person health [29]. According to NCCIH, "complementary" in complementary and alternative medicine refers to non-mainstream practices used in conjunction with conventional medicine, and "alternative" refers to non-mainstream practices used instead of conventional medicine. It's important to distinguish between the two because complementary medicine is used alongside standard care, while alternative medicine is used instead of conventional care. Integrative health is a treatment that harmoniously combines conventional and complementary approaches. It emphasizes complex interventions that combine two or more interventions, such as medication, physical rehabilitation, and psychotherapy, with complementary approaches such as acupuncture, yoga, and probiotics. Holistic health extends beyond the treatment of disease to improving the health of individuals, families, communities, and populations across multiple interconnected domains: biological, behavioral, social, and environmental. It involves understanding the connections between different aspects of health.

2.3.2. NCCIH's Classification of Complementary Medicine

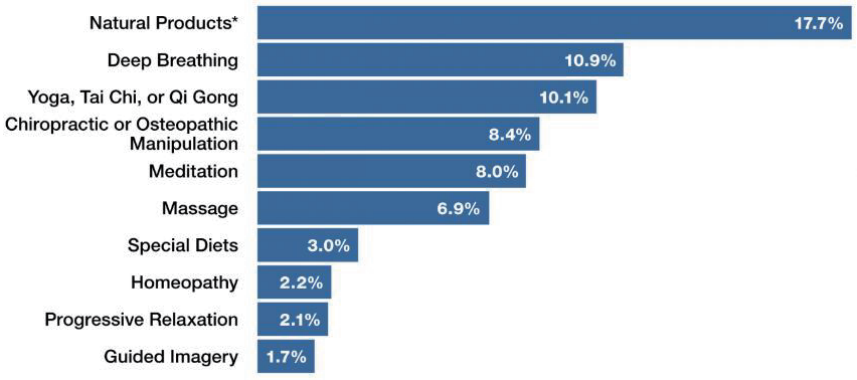


Figure 2. 10 Common Complementary Health Approaches – 2012 [30]

The 2012 National Health Interview Survey (NHIS) [30], which includes a comprehensive survey of Americans' use of complementary medicine, reports that Americans are actively utilizing a variety of complementary medicines in parallel with conventional medical approaches. This trend reflects the growing importance of complementary and integrative healthcare in healthcare.

According to the NCCIH, complementary medicine, which is non-mainstream medicine, can be categorized according to various treatment modalities. These include nutritional approaches, psychological approaches,

physical approaches, and combinations of each. Nutritional approaches include diet, weight loss, dietary supplements, herbal remedies, probiotics, and more, also known as natural products. Psychological approaches include mental health improvement methods such as meditation and mindfulness. Physical approaches include physical therapies such as massage and spinal adjustments, and combined psychological and physical approaches include yoga, tai chi, acupuncture, dance and art therapy, mindful eating, mindfulness-based stress reduction programs, relaxation techniques, qigong, hypnotherapy, Alexander Technique, and Pilates. The herbs, vitamins, minerals, and probiotics included in nutritional approaches are publicly accessible and often sold as dietary supplements. Combined psychological and physical approaches, such as tai chi, yoga, acupuncture, and massage therapy, are often taught or practiced by professionals or teachers and can be helpful for a variety of health issues. Research has shown that acupuncture can relieve chronic pain, arthritis, and more; yoga can help with general well-being, including relieving stress and supporting healthy habits; and meditation can be beneficial for reducing blood pressure and improving anxiety, depression, and insomnia. In addition, some complementary medicines, such as Ayurveda, Chinese medicine, homeopathy, naturopathy, and functional medicine, do not fall under the NCCIH's specific classification but are widely used. Each of these modalities is used selectively for specific health conditions.

3. Developing a Whole Person Health Model

3.1.Structure and Elements of a Health Model

Figure 3. is a schematic model of whole person health that complements and organizes the core of Unification Thought and Ken Wilber's four quadrants of integrative medicine. The whole person health model is divided into four parts by a coordinate axis (x-axis, y-axis), with the upper part of the x-axis divided into individuals and objects, the lower part into groups and environments, and the lower part of the y-axis divided into internal on the left and external on the right. The first quadrant on the right corresponds to Western medicine. It is a medical system that is primarily concerned with the external aspects of the individual and is associated with a reductionist worldview. The second quadrant on the left corresponds to complementary medicine. It''s primarily concerned with the inner life of the individual and is associated with a holistic worldview.

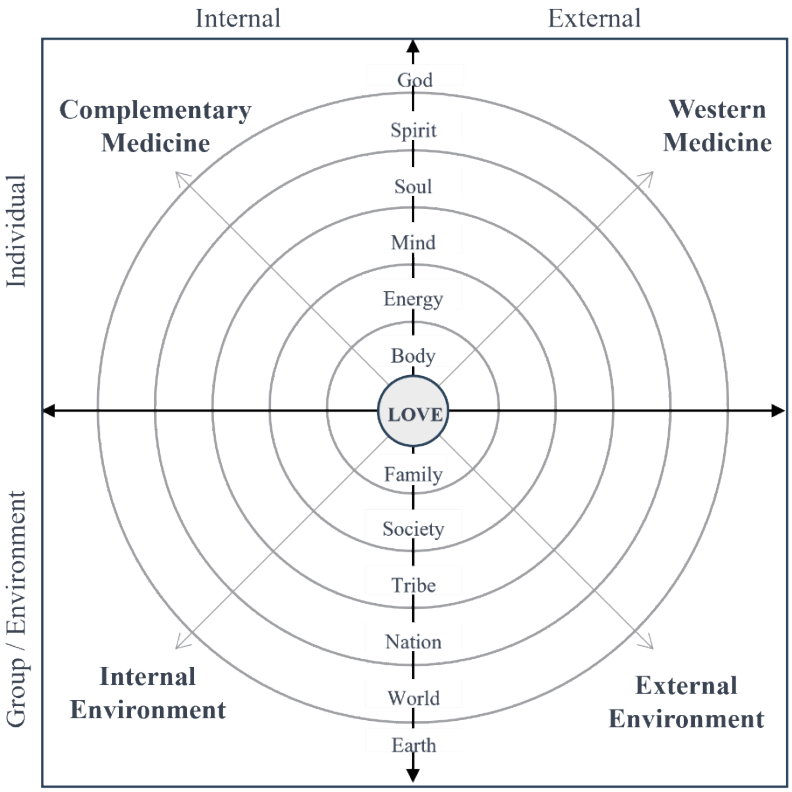


Figure 3. Whole Person Health Model.

The lower left quadrant is the inner aspect of groups and environments, relating to the family, society, tribe, nation, world, and global environments that surround the individual, and culture. The lower right quadrant is the external aspect of the group and environment and can be related to the economy, institutions, policies, etc.

The center of the quadrant is love. Love is an essential source of power that exists at the center of humans and all things, and is a key requirement for health as advocated by Unification Thought. There are six realms centered around love. The top represents the level of human consciousness, progressing from body, to energy, to mind, to soul, to spirit, to God. The bottom level is the environment surrounding the individual. It extends to the family, society, tribe, nation, world, and global environment.

The integration of Western and complementary medicine at the top is described as a holistic worldview. Ken Wilber's holism views the universe and the evolution of life/consciousness as a holarchy in which each part is both a whole and part of a greater whole. He emphasizes that the impetus for the emergence and evolution of life/consciousness comes from the spirituality of life, and that everything in the universe is interconnected to form a complex, multidimensional system, indicating that every aspect of the universe contributes to the vast web of life. From this perspective, the spectrum of consciousness at the top is consistent with the concept of Panca-Kosha from the ancient Indian scripture, the Taitiriya Upanishad. Panca-Kosha describes the five layers of human existence: the physical layer, which is nourished by food; the energy layer, which consists of breath and prana; the mind layer, which includes emotions and thoughts; the wisdom layer, which is related to intellect and insight; and the bliss layer, which represents spiritual peace. Enveloping the bliss layer is the atman, or supreme God. Ken Wilber agrees that there is an infinite reality behind, beyond, above, within, and as the entire manifested universe [26].

3.2.Western and Complementary Medicine in the Health Model

Western medicine is a modern medical system based on biological principles that scientifically explores the causes and treatments of disease. It consists of basic sciences, such as anatomy, physiology, and biochemistry, and clinical medicine, which focuses on bodily functions and pathologies. Western medicine aims to identify the specific cause of a disease and treat it directly with medication, surgery, and other methods. Therefore, it's not easy to connect it to holism. However, we can categorize them as follows

The body is connected to general medicine and surgery, and the qi to internal medicine, which deals with energy regulation and metabolic processes. Mind can be assigned to psychiatry, soul to medical ethics, and spirit to palliative care, which focuses on quality of life and spiritual well-being, and includes chaplaincy services and counseling to meet the spiritual needs of patients, especially in difficult situations. From the perspective of medical disciplines, subjects such as anatomy and physiology correspond to the body, biochemistry to the qi, behavioral sciences to the mind, and neuroscience to the soul.

Complementary medicine is an important part of a holistic health model that includes a variety of therapies used in conjunction with Western medicine. It encompasses the body, energy, mind, wisdom, and spiritual aspects, and promotes physical health through diet, including enzyme therapies such as probiotics and prebiotics, and manual therapies such as chuna, chiropractic, osteopathy, Thai massage, acupressure, taping, and foot reflexology.

In the chi realm, energy is regulated through herbal treatments such as acupuncture and moxibustion, energy therapies such as qigong, reiki, tai chi, and sound therapy, and the use of technology such as electrical and magnetic stimulation.

Mental health is promoted in a variety of ways, including mindfulness interventions such as MBSR, MBCT, ACT, and MSC; psychotherapies such as CBT, DBT, coaching, and counseling; and mind-body practices such as meditation, yoga, and hypnosis.

In the realm of the soul, deep self-understanding and wisdom are explored through semantic therapy, gestalt therapy, vipassana, transcendental meditation, and kriyayoga. In the spirit and God realm, spiritual and transcendent experiences are sought through spiritual retreats, pastoral counseling, Kabbalah, Sufism, meditation, and specific spiritual practices. While we have categorized some types of complementary medicine in this study, many of these therapies address different aspects of human existence through a multidimensional approach, so there may be overlap across multiple dimensions. For example, yoga and meditation can be categorized as mindfulness because they benefit mental health, but they also affect the body, and they can also be categorized as spiritual and divine.

This multidimensional approach of complementary medicine is key to addressing human health and well-being holistically. Each therapy interacts with the physical, energetic, mental, intellectual, and spiritual components of an individual, reflecting the basic principles of a holistic health model that recognizes health as more than just a physical condition. In this way, complementary medicine contributes to comprehensive health care and treatment that goes beyond the limitations of conventional Western medicine, and supports people in living a full and harmonious life as a whole. As such, complementary medicine plays an important complementary role to modern medicine and makes an important contribution to the promotion of overall health and well-being.

Table 1. Items and highlights of the whole person health model quadrants

Complementary medicine	Levels	Western Medicine
Specific spiritual practices, etc. Spiritual retreats, pastoral counseling, Kabbalah, Sufism, meditation, etc.	God / Spirit	Palliative care, chaplaincy services, and counseling
Meaning therapy, gestalt therapy, existential therapy, Vipassana, Transcendental Meditation, Kriyayoga, etc.	Soul	Medical ethics
Mindfulness Based Interventions such as MBSR, MBCT, ACT, MSC, CBT, DBT, coaching, counseling, etc. Psychotherapy, meditation, yoga, hypnosis, etc.	Mind	Psychiatry
Korean medicine such as acupuncture and moxibustion, energy therapies such as qigong, reiki, tai chi, color therapy, sound therapy, etc.	Energy	Pulmonology and Endocrinology
Diet, including enzyme therapies such as probiotics and prebiotics, manual therapies such as pranayama, chiropractic, taping, and tui na.	Body	General Medicine and Surgery
Internal environment	**LOVE**	**External Environment**
Family ties and positive culture, emotional support, and conflict resolution skills	Family	Economic stability, safety in housing, family medical history
Social support and sense of community, social networks and belonging, and social inclusion	Society	Public health systems and access to care, education and job opportunities, social safety nets, and community health infrastructure
Health beliefs based on cultural traditions, sense of belonging and identity, and understanding and respect for traditional values	Tribes	Racism and healthcare access inequities, Ethnically specific health campaigns
Awareness of public health, national identity, health literacy	Nations	Healthcare infrastructure, health insurance systems, national health policies and programs, and government investments in health promotion
Sense of global citizenship and solidarity, awareness of global health issues	World	The role of international health organizations such as the WHO, Global initiatives, international epidemic response and coordination
Sustainable living, living in harmony with nature, environmental responsibility	Earth	The effects of climate change, including natural disasters and infectious disease outbreaks, Sustainable resource management, global environmental protection policies

3.3.Internal and external environments for whole person health

Whole person health starts with recognizing that an individual's health is a multifaceted phenomenon that is influenced by a complex set of internal and external factors. This whole person approach is essential for a comprehensive understanding of health and healthcare. In this study's whole person health model, we categorize the environment into six domains that encompass both the internal and external environments. In the first domain, the home, internal dynamics such as emotional bonding, family communication, and conflict resolution skills

play an important role in shaping an individual's health. In addition, external factors such as economic stability and safe housing contribute significantly to well-being.

In societies, internal factors such as social support networks and community engagement influence health, while external factors such as the availability and quality of public health services, education and employment opportunities, social safety nets, and community health infrastructure affect the overall health of individuals in a society.

Within an ethnic or racial context, internally, cultural practices and shared beliefs influence health behaviors and attitudes, and issues such as access to healthcare and racial discrimination in the healthcare system can affect the health of individuals in that community.

The national perspective emphasizes people's perceptions of public health and national identity, and the quality of healthcare infrastructure and national health policies play a pivotal role in shaping a country's health environment.

At the global level, global citizenship and solidarity play an important role in addressing global health challenges. In particular, the role of international health organizations and global initiatives to combat infectious diseases and address global health challenges is important.

Finally, the global environmental context calls for living in harmony with nature, sustainable lifestyles, and personal responsibility for the environment. Furthermore, the impact of the climate crisis and global environmental policies have a major impact on human health.

At the center of many factors that directly or indirectly affect health is love. It strengthens emotional ties between families, promotes inclusion in social settings, and honors cultural diversity. It is also a key force on many levels, from supporting national health initiatives to strengthening global health cooperation, encouraging responsible environmental stewardship, and fostering global solidarity on health issues.

In short, whole person health requires a comprehensive consideration of the individual and the various circumstances that surround them. Above all, it is love that has the power to recognize this complex web of factors and strengthen the interconnections between them.

4. Conclusion and discussion

This study emphasizes the importance of a whole person health model that fuses Unification thought with Ken Wilber's integrative medicine system. This model proposes a multidimensional approach to health that centers on true love and balances the health of the body, mind, and spirit. This integrative approach provides a new understanding of health and contributes to the promotion of holistic well-being.

Through the development of a whole person model of health, the book explores how to understand and promote health in a multidimensional way, encompassing various aspects of human existence and extending health beyond physical conditions. In particular, it is expected to contribute to improving the overall health and well-being of individuals by providing an integrated approach to health care that transcends the boundaries of Western and complementary medicine. Furthermore, it emphasizes that the consideration of health is not limited to the individual, but is possible in a complex interaction with various environmental factors surrounding human life, including the family, society, tribe, nation, world, and global environment, with true love as the driving force at the center.

Limitations of this study include the limited scope of applicability to specific cultural contexts and populations. In addition, there is still a lack of long-term and extensive empirical studies to verify the practical effectiveness of the theoretical model used. Future research should evaluate the applicability of the model in different sociocultural contexts and further explore the validity of the model through clinical studies in a wide range of populations and different health situations. These studies will expand the universality of the model and contribute to the development of more targeted health interventions.

In conclusion, this study provides a deeper understanding of a new approach to health care, which can help health professionals better address the complex needs of patients. It is also expected to contribute to human well-being by offering patients a more comprehensive approach to health care and treatment.

References

1. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 136. (Sunghwa Publishing House, 1985).
2. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 197. (Sunghwa Publishing House, 1990).

3. The Holy Spirit Association for the Unification of World Christianity. *The Divine Principles* (Sunghwa Publishing House, 1994).
4. Lee, J. Y. *Won Buddhist Teacher Image and Religious Culture 69*, 457-481 (2016).
5. Family Federation for World Peace and Unification. *Cheon Seong Gyeong* (Sunghwa Publishing House, 2013).
6. Unification Thought Research Center. *Unification Thought* (Sunghwa Publishing House, 1982).
7. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 199. (Sunghwa Publishing House, 1990).
8. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 203 (Sunghwa Publishing House, 1990).
9. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 119 (Sunghwa Publishing House, 1982).
10. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 164 (Sungwa Publishing House, 1987).
11. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 54 (Sunghwa Publishing House, 1972).
12. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 105 (Sunghwa Publishing House, 1979).
13. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 217 (Sunghwa Publishing House, 1991).
14. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 333 (Sunghwa Publishing House, 2000).
15. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 92 (Sunghwa Publishing House, 1977).
16. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 430 (Sunghwa Publishing House, 2004).
17. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 178 (Sunghwa Publishing House, 1988).
18. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 470 (Sunghwa Publishing House, 2004).
19. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 222 (Sunghwa Publishing House, 1991).
20. Moon, S. M., *World People Who Love Peace* (Kim Young-Sa, 2009).
21. Family Federation for World Peace and Unification *The Unification Church and Its Members* (Sunghwa Publishing House, 1998).
22. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 205 (Sunghwa Publishing House, 1990).
23. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 57 (Sunghwa Publishing House, 1972).
24. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 87 (Sunghwa Publishing House, 1976).
25. Moon, S. M. *Anthology of words of Rev. S. M. Moon*, 118 (Sunghwa Publishing House, 1982).
26. Wilber, K. *The integral vison: A Very Short Introduction to the Revolutionary Integral Approach to Life, God, the Universe, and Everything* (SHAMBHALA PUBLISHING, 2007).
27. Wilber, K. *Integral Psychology: CONSCIOUSNESS, SPIRIT, PSYCHOLOGY, THERAPY* (SHAMBHALA PUBLISHING, 2000).
28. World Health Organization. https://www.who.int/about/accountability/governance/constitution (accessed January 10, 2024).
29. National Center for Complementary and Integrative Health. https://www.nccih.nih.gov/health/complementary-alternative-or-integrative-health-whats-in-a-name (accessed January 10, 2024).
30. Clarke, T. C. et al. Trends in the use of complementary health approaches among adults: United States, 2002-2012. *Natl Health Stat Report 10*(79), 1-16 (2015).

Proceedings of
THE 3rd INTERNATIONAL CONFERENCE OF
HYOJEONG ACADEMY 2024

Session 6

Religious Studies

www.lchja.org

Can We Formulate a Religion Based on Science and Vice-versa?

Lalit Mohan Kukreja* and Detty Alappat Pathrose

Epi-knowledge Foundation, Vashi, Navi Mumbai 400703, India
*Correspondence: drlm.kukreja@gmail.com

Abstract: Science is objectivity and evidence-based knowledge about nature, whereas religion is faith and belief based on experience and feelings. Science is necessary for modern living, our wellbeing and survival; religion is necessary for overcoming the mental stress due to fears of unknown and ethics for our collective co-existence. While both are products of social collaborations and understanding, human psychology plays an important role in their implementation. We explore if science and religion be unified despite these dichotomies. We also propose formulation of a religion based on science and vice-versa. The basis of creation and existence in science is fundamental forces of nature, like gravity, electromagnetic, nuclear and the rest of those. Some of these forces are well understood and others are not yet known or understood. As we evolve evidence-based knowledge about nature some of the unknowns migrate from the domain of religion to the domain of science and become knowns. This migration is dynamic and irreversible. Therefore, we find that religion and science are indeed complimentary to each other and hence should be mutually adaptive. If religion can adopt these fundamental truths of nature and science can accept its limitations of providing solace to humanity due to unknowns of nature, a consonance between the two can emerge.

Keywords: science, religion, fundamental forces, faith and belief, mutually adaptive

1. Introduction

Nature produces, sustains and destroys human beings. From the beginning to the end, life is a game of nature. It is therefore important to understand nature as the central point of human life and its myriad of associated ramifications. These ramifications can be put in the form of questions like, how and why did human beings come into existence? What is the purpose of life? How did human transform from the earlier primitive form to the modern scientific and technological life form? Is life in its current form sustainable or do we need to change our ways for a better world for our future? Today these questions fall within the purview of science, because primarily it is science and its philosophy which has reached to an adequate level to understand and unlock the mysteries of nature. Even then these questions can be answered in a limited way because many pertinent aspects are known, some are partially known and others are not known at all. This is the strength of science that it openly admits that what we know is finite and therefore unknowns are infinite.

Ever since the dawn of humankind, the developed form of human brain and the mind played a crucial role in fulfilment of the most basic instincts of survival through food, shelter for protection and reproduction etc. It is plausible that the primitive man in the wild had to struggle for these basic needs and there was no need for advanced social ventures such as economics, finance, politics, religion and science. As the human population and experiences grew these higher needs became imperative and through its developed mind humanity advanced these systems of social interactions. When fears of unknowns like diseases, natural calamities and death became stress, and ethics in social, financial and political dealings became inescapable the foundation of religion must have been laid. Later religions became organized sectors through experiences over ages and some of the religions became dominant and authoritative social setups to which populations subjugated. Over the course of time, certain religions and empires were unified to become authoritative and powerful that disobeying their dogmas and diktats were punishable offense, even to the extent of death sentence. Sometime during such dark ages of humanity certain courageous truth-seeking individuals established and advocated the truths of nature which came to be known as science.

Although science in its modern form originated much after the religions, at least a few thousand years, it quickly became an entity to be reckoned with. However, there was a stark contrast between the two. Science was

perceived anti-religion. This was because some of the religious dogmas and rituals were not founded on evidence-based truths of nature, rather those were based on orthodox, unwarranted beliefs, and science did not encompass the areas of human psychology such as love, compassion, ethics, forgiveness necessary for human peace and co-existence. Because these areas of psychology were very well perceived and adopted by humanity in religions, those were embraced as great principles of life. As a result, there existed a deep-rooted and unshakable submission by the followers to those religions while the foundation of modern science was being laid. Subsequently science progressed rapidly, decisively and it led to industrial and agricultural revolutions in the middle of 18th century [1]. This proved to be the real saviour of mankind for food, clothing, shelter and medical care to not only provide scientific treatment for diseases but also enhanced life expectancy. Since science offered evidence-based understanding of nature, people started believing in science and religion became a parallel system for all those domains where science could not provide any credible path. However, still the religion and science could not be put in the same basket. While science gave birth to technologies for life like modern transport, residential and commercial buildings, food, communications, clothing etc. and created humongous job opportunities, it has not yet answered the questions such as origin of life, understanding of death, ethics and most importantly the origin of psychological disorders and defilements, and the traumas generated due to those. On the other hand, religions proved to be offering some subjective solutions to such problems, mostly psychological. As a result, the religions are still important for the humanity despite a colossal success of science. Of course, there are a significant number of people who are atheists or non-believers, which doesn't undermine the realms of religions significantly. In this paper we propose a science-based model of religion and vice versa to bring a consonance between the two in an effort to elicit these entities which are the best of both worlds. While science should work on the areas of religions and accept its own limitations, the religions should adopt the logical findings of science to benefit the humankind comprehensively. The possible routes to this model and its different nuances will be presented and discussed in this paper.

2. Scientific views on creation, existence and annihilation

Creation, existence and annihilation are the three most fundamental processes of nature which concern humanity at every level. Therefore, these subjects are common to both science and religion. In science, despite the colossal efforts to understand these fundamental processes of nature it is still not known that how energy and matter are created [2]. As we understand, it is the fundamental forces such as gravitational, electromagnetic, nuclear and the rest of these which are responsible for the existence of matter in its current state and its destruction at microscopic and macroscopic scales. But we are aware of the fact that science has not yet elicited and understood all the kinds of fundamental forces of nature. As mysterious as it is, the ex-nihilo creation of matter and energy is actually an area about which we are scientifically clueless. Are there some forces in nature which have the capability to create energy and matter ex-nihilo and do we not yet know such forces? This is the point that bothers scientists even today.

Creation, existence and end of life is even more mysterious because of one more parameter i.e., consciousness. How non-living elements become living organizations is a subject of infinite mystery. Is there a force in nature that creates consciousness in the aggregated elements of cosmos? What are the prerequisites and conditions under which non-living elements become part of a living entity? These questions are baffling even to the most brilliant minds of today and had been bothering in the entire history of science. One reason for this is that the living beings are so intricate and so perfect in design and functioning per se, that it is impossible to believe that nature could create such living organisms in primitive and advanced forms through any random or accidental process. It appears as if there is some highly intelligent force in nature which designed and created the myriad forms of sentients, the most intricate of those being humans. What is that force? Is it the same force which in the field of religion people call as ‘God’? The scientists think that we do not yet know any such force nor we are closer to find such a force at the moment. We may mention that the myriad of life forms that we have talked about here are the ones that we observe on our planet Earth, while we do not exclude the possibilities of existence of other forms of life somewhere else in the gigantic galaxies of the universe.

3. Why is religion important?

As discussed in Section 2 above, objectivity of science necessitates that we have yet to search the forces or its alternatives responsible for creation of matter, energy and life. Although we have not yet succeeded and puta-

tively the efforts are going on in identifying such forces or its alternatives, it doesn't mean that we have to live with the stress of this yet unknown. So how do we get peace, love and joy of living within the myriad of such unknown forces? A further extension of these unknowns encompasses the uncertainties of life and death which creates a psychological fear and restless mind. Lower animals of nature simply follow the basic instincts to manage their fears of life and death. Advanced brain and mind of human beings are assets for dealing with such problems, for example, through medication. However, the same developed mind can also create a source of enhanced fears and other defilements such as violence, corruptions etc. Such stresses can sometimes be life threatening to oneself or even to others. If there were no fears, greed, corruptions etc. the human mind by nature would be peaceful, loving and joyous. It is the tenets of religion which are supposed to bring peace and joy of life despite fears, greed, violence and corruptions. Traditions such as faith in God, love, compassion and forgiveness, meditation for peace and joy, prayers for universal well-being are the human practices which bring about psychological relaxations despite so much of violence, unjust, unrest and prejudices and biases in the society and even natural calamities such as diseases, pandemic, earthquakes, hurricanes, flood etc. Religions transform the fears of unknowns such as death due to accidents or natural calamity into submission, obeisance and love for God. As we know religion and its concept of God is a creation of human mind for achieving the noble purpose of peace and joy of living. As per the tenets of religion if one has submission, obeisance and love for God, God protects them from the agonies and sufferings caused by the unknowns such as uncertainties of natural calamities, diseases, financial losses, vilification etc. Because these tenets of religion is effectively working since ages, religions have an important role to play in human life even though science does not yet provide any basis for it. Therefore, religions are as important as science for a comprehensively good living.

Religion has one more profound positive effect on the collective co-existence, that is ethics and morality [3,4]. While science has not yet ventured into evidence-based knowledge on the necessity of ethics and morality, religions preach these great qualities of human beings as necessary components of submission, obeisance and love for God. As we know that for our peaceful co-existence and shared prosperity ethics and morality are essential the importance of religion is self-evident. Some scholars tend to think that morality and ethics can be independent of religion [3] but for common masses this doesn't seem to be so. As stated above religions invoke the feelings of submission, obeisance and love for God, this in turn naturally brings about the feelings of ethics and morality in the individuals [4].

4. How to formulate a religion based on science?

Having stated the basic tenets, different ramifications and rules of science and religion in human life let us now discuss the possibility of formulation of a religion that is consistent with science and vice versa. Basically, the central component of religion should be that which human being believe, subjugate and practice with full devotion so that their psychological stresses are mitigated and morality and ethics come to the fore in routine behavior. At the same time such a religion should have a logical veracity of science which means objectivity, universality even though its complete understanding might be still unknown or partially known. We propose that the nature is that entity. Nature is real, true, the creator, the sustainer and the destroyer. The nature is in everything and everything is in nature. So, in a religion conforming to the tenets of science and vice versa nature should be the supreme power. In the religion of science, we understand nature, we submit ourselves to nature, we love nature and we worship nature.

Nature worship is not alien to humanity; it has been practiced in many traditions [5] since the beginning of human civilization. However, it could not become an organized universal practice perhaps because of lack of understanding of its fundamental tenets or unappealing profoundness of its rituals and modus operandi [6]. Nature worship was more common at the dawn of humanity and its culmination into a social set up, and now it has been practically completely replaced by other religions. Religion of science is supposed to be more comprehensive which includes the studies in sciences, especially the life sciences, and the practices of spirituality such as mediation, oneness of mankind living in communion with nature and practices to preserve and use the resources of nature prudently. Similarly, science based on religion should accept that everything is not yet known in science and practices to counter the adverse effects of unknowns may be encompassed in the domain of religion. As those unknowns become knowns through scientific studies those migrate from the domain of religion to the domain of science. This migration is plausibly dynamic and unidirectional.

5. Conclusions

In the preceding discussion we have shown that science and religion are not in conflict with each other, rather they are complementary to each other. Both of these are necessary ingredients for the peaceful co-existence of mankind. While science agrees that our ignorance about understanding of the nature is still infinite, the religion agrees that scientific studies are the answers to unlock the mysteries of nature. In a science-based religion nature should be the supreme power and we adopt the known practices of spirituality and religions, keeping nature at the central stage. We conclude that nature-centric religion is the religion of science and it has the capacity to provide the expected peace, harmony and joy of living collectively for making this planet a better place. While both science and religion are products of social collaborations and understanding, human psychology plays an important role in their implementation. Therefore, religion-based science should adopt the natural tenets of religions such as ethics, morality and psychological practices for peace, harmony and joy of co-existence.

Author Contributions: LMK is responsible for conceiving, contemplating and formulating the content of this paper and DAP reviewed the contents and contributed in composing the manuscript.

Acknowledgments: We thank Prof. Young Sik Pyun, Sun Moon University, Korea for his encouragement to write on the subject of science-religion unification and for introducing us to the Hyojeong Academia and its noble objectives.

Conflicts of Interest: The authors declare no conflict of interest in this paper.

References

1. Industrial History of European Countries. European Route of Industrial Heritage. Council of Europe. https://www.erih.net/how-it-started/industrial-history-of-european-countries (accessed on 2 January 2024).
2. Sagan, C. *Cosmos* (Ballantine books, 2013).
3. McKay, R. and Whitehouse, H. Religion and morality. *Psychological 141*, 447–473 (2015).
4. Wikipedia: Morality and Religion. https://en.wikipedia.org/wiki/Morality_and_religion (accessed on 04 January 2024).
5. Wikipedia: Nature Worship. https://en.wikipedia.org/wiki/Nature_worship (accessed on 04 January 2024).
6. Hutton, R. *The Triumph of the Moon: A History of Modern Pagan Witchcraft* (Oxford University Press, 2019).

The relationship between man and woman, husband and wife, viewed through the principles of Yin and Yang and the reciprocal subject partner-object partner dynamics

Sun gu Kwon[1,*], Yeon Taek Choi[2] and Aeryeon Lee Hokanson[1]

[1] Office of university chaplains, Sun Moon University, Asan 31460, Korea
[2] The Good Dream Counseling Center, Chonan, Korea
* Correspondence: kwonsungu2@naver.com

Abstract: In East Asia, Yin-Yang philosophy, a representative philosophical system, did not originally include the concept of "Jonbi" or hierarchical subject-object relationships. However, with the integration of Confucian influences, particularly from Neo-Confucianism, the Unification Movement also known as the Family Federation for World Peace and Unification incorporated the Jonbi concept. Within the Family Federation for World Peace and Unification, influenced by Confucian ideals, gender roles, and marital relationships were defined as absolute subject partner–object partner relationships in their original forms. As a result, the Unification Movement's subject partner–object partner concept, based on Confucian principles, reflects a significant discrepancy with contemporary ideals of gender equality. Reinterpreting the subject partner-object partner relationships within the context of Yin-Yang philosophy, which emphasizes balance and mutual interaction, could offer a valuable theoretical framework for addressing current challenges in gender relations and marital dynamics. By shifting the focus from hierarchical relationships to reciprocal relationships centered around Yin-Yang philosophy, this reinterpretation may present a solution to the existing issues between men and women and husbands and wives. The Family Federation's subject partner-object partner concept, when viewed through the lens of Yin-Yang philosophy, has the potential to become a constructive theory for resolving gender conflicts and marital problems in today's society.

Keywords: Yin-Yang, subject partner–object partner, Reciprocal Relationships, Marital Relationships, Family Federation.

1. Introduction

Yin-Yang theory, a representative ideological system in East Asia, can be seen as included in the concept of subject-partner and object-partner in the Family Federation for World Peace and Unification (hereinafter referred to as the Family Federation). However, while yin-yang theory focuses on explaining the existence of objects, there is a difference in that the subject and object are explained by focusing on personality, the mental world, and mutual relationships. Therefore, if we distinguish between the yin-yang theory and the subject partner–object partner theory based on the yin-yang theory, the yin-yang theory can be a relatively material-oriented yin, and the subject partner–object partner theory can be a relatively spiritual-oriented yang. In yin-yang theory, if there is yin, there must be yang. If a hill on which the sun shines is positive, the shade on the other side becomes yin. Also, in the case of positive sunlight, the places where relatively more sunlight shines are positive, and the places where there is less sunlight are negative. Therefore, there cannot be yang without yin, and there is no yin without yang.

In the yin-yang theory, there was no absolute yin and yang in Taoism, and there was no idea of respect for the yin, which regarded the heaven of yang as "Jon" (high) and the earth of yin as "bi" (low). It can be said that the role of neo-Confucianism, which expanded and interpreted the relationship between yin and yang, was largely responsible for the later distinction of yin and yang being conceptualized to explain social phenomena and establish itself as a guiding ideology. In Confucianism, the phenomenon of yin and yang is expressed as reciprocal or relative [1].

The reciprocal relationship in Confucianism focuses on achieving harmony through interaction rather than the literal meaning of opposing things facing each other [2]. Confucianism, which defined yin-yang theory as a reciprocal relationship, made a very positive contribution, but it also had the side effect of creating an ideology of male superiority over females due to the erroneous idea that yang is precious and yin is inferior.

The subject partner–object partner theory of the Family Federation, as it appears in the current Unification Thought, acknowledges the hierarchical differences, akin to recognizing the Confucian principle of Jonbi (high and low) in the context of Neo-Confucianism. However, it has limitations in presenting solutions to gender conflicts between men and women or role conflicts between spouses. Therefore, it can be argued that the subject partner–object partner theory of the Family Federation, influenced by Confucian ideology, particularly the patriarchal views of Zhu Xi, needs reinterpretation. Rather than adhering to a fixed position of absolute subjectivity and objectivity, it is necessary to reinterpret it as a reciprocal relationship where roles can change depending on the circumstances.

In this study, we have proposed that many issues related to gender and marital relationships that cannot be resolved by the male-centric subject partner–object partner theory in Unification Thought could find resolution through the reinterpretation of reciprocal relationships based on the principle of subject-partner and object-partner. This study does not delve into the exploration of the existence of God from the perspective of Yin and Yang principles, nor does it discuss the relationship between God and humans in terms of the subject partner – object partner relationship.

2. Yin and Yang Theory

The predominant philosophical system in East Asia, Yin, and Yang theory, initially developed as an independent ideology and later evolved into the philosophy known as Yin-Yang and the Five Elements, alongside the theory of the Five Elements. Yin and Yang, representing the primal forces, initially began as a distinction in the primitive era, reflecting human perspectives on the visible and invisible things, sensations of warm things, and cold things felt by the touch. As time progressed, human cognition advanced, societies became more intricate, and the need for distinguishing various elements increased, leading to the development of a complex conceptual framework.

Yin and Yang theory can be traced back to primitive times when humanity discerned the basic duality of light (Yang) dispelling darkness (Yin), akin to the sun illuminating and transforming shadows into brightness. The origin of the Yin and Yang philosophy, originating in China, is akin to the emphasis on light related to the sun. Similarly, in the Book of Genesis in the Bible, light and darkness are also presented.

> In the beginning, God created the heavens and the earth. God said, "Let there be light," and there was light. God saw that the light was good, and he separated the light from the darkness. God called the light "day," and the darkness he called "night." And there was evening, and there was morning—the first day [3].

In this way, the concept of Yin and Yang, emerging across different eras and regions, can be directly related to human life.

As evident from the above, the original meaning of Yin and Yang was closely associated with the sun. Consequently, it was often expressed by referring to the warmth and coldness influenced by the sun in the weather. This connection is notably linked to the occurrence of the four seasons. Therefore, the development of Yin and Yang is considered to have evolved under the guidance of astronomers who observed celestial phenomena [4]. This fact can be confirmed by the fact such information is not found in representative classics of the Confucian tradition, such as the "Analects of Confucius," "Doctrine of the Mean," and "Mencius." [5]

The early Yin and Yang philosophy originated from explaining natural phenomena but progressed to elucidate the interaction of certain facts dimensionally, particularly through its encounter with the Five Elements theory. Subsequently, with the integration of Confucianism, it expanded its scope to explain natural phenomena such as creation and extinction and extended to elucidate rites that explain human duties. In Confucianism, Yin and Yang were often distinguished as good and evil, prior and posterior, among other classifications [6]. This expansion of the scope of Yin and Yang philosophy was made possible not only through its encounter with the Five Elements but also through its application in interpreting the Book of Changes [7].

The concept of Yin and Yang philosophy emerges differently in Taoism and Confucianism. In Confucianism, particularly in the "Book of Changes", the "Sequence of Hexagrams" states, "Heaven is noble, and Earth is lowly. The positions of Heaven as Yang and Earth as Yin are determined," [8] expressing the hierarchical relationship between Yang and Yin [9]. On the other hand, Taoist philosophers like Laozi and Zhuangzi do not distinguish between Yin and Yang.

The Yin-Yang perspectives in Confucianism and Taoism are not matters of right or wrong but rather subjective perceptions among scholars of that time. However, considering the present context, the Taoist view of Laozi, which does not assign higher or lower status to Heaven and Earth, seems more valid today than the Confucian idea of distinguishing Heaven and Earth in terms of superiority and inferiority.

Yang and Yin, rather than a one-dimensional approach that distinguishes between before and after, high and low, good and evil, hold significance in forming a mutually reciprocal relationship. This allows them to serve as tools for understanding the principles of change in nature and all things due to creation and destruction, as well as elucidating the diverse aspects exhibited by humans throughout their lives. While Confucianism metaphorically differentiates Yang and Yin as Heaven and Earth, their coexistence emphasizes the reciprocal relationship where Earth must exist for Heaven to exist, and vice versa.

The widespread Yin-Yang philosophy, originating in East Asia, particularly in China, has its roots in an observational understanding of nature, evolving into a metaphysical framework explaining natural phenomena and ethical norms related to human life. It is important to note that it did not develop into a religious dimension associated with the unseen Heaven. Therefore, there is a distinction between the Yin-Yang theory advocated by the Family Federation and the traditional Yin-Yang philosophy.

3. Husband and wife viewed as subject partner and object partner

God is a Being who is absolute, unchanging, eternal, self-existing, and omnipresent. He exists as a central subject with intangible dual characteristics, and is a subjective entity regarding the spiritual world, while the physical world constitutes the objective entity of God [10]. In essence, God is the subject concerning the physical world, and all entities in the physical world, including humans, are the objects. In terms of the relationship between God and humankind, the Family Federation assumes that God is a masculine subject in terms of nature, while the physical world is a feminine object in terms of form. Additionally, they posit that the relationship between masculinity and femininity is analogous to the relationship between internal nature and external form, and the positive-negative relationship is seen as having relative aspects, such as internal nature-external form, cause-effect, subject partner – object partner, and so on [11].

In Unification Thought, it is emphasized that there should be a hierarchical difference between subject and object, and the absence of such a hierarchy could lead to confusion [12]. In summary, the Family Federation incorporates a worldview that doesn't differentiate the value of the subject and the object, contrasting with the hierarchical distinction between Heaven and Earth in traditional Confucian thought, which aims to maintain social order while acknowledging the importance of role distinctions based on hierarchical positions [13].

Meanwhile, in the Unification Thought, the concept of subject and object is applied not only to the relationships between humans and all things (objects), humans and humans, and objects and objects but also extends to four types as follows:

Firstly, it recognizes the universal subject partner–object partner relationship that is eternally established as the original form. An example given is the relationship between husband and wife.

Secondly, it introduces the provisional form, where the subject partner–object partner relationship is temporarily reversed based on circumstances. In such cases, the original form is not considered to be extinguished.

Thirdly, it discusses a case where the subjective roles are changed in an interactive manner in which the subject partner and object partner change depending on the situation.

Lastly, it distinguishes a negative form that needs to be determined arbitrarily by the evaluator [14].

From the above, God, as the position of Yang, is in a subjective position, designating humans and all things in the position of Yin as object partners. Moreover, in the marital relationship, husband and wife are defined as the unchanging subject partner and object partner, with a distinction in their respective positions.

In the above, God, who is in the Yang position, is defined as the subjective position, and humans and all creation, who are in the Yin position, are defined as objects or object partners. In addition, the husband and wife in a marital relationship were defined as an immutable subject partner and object partner, and it was said that there was a difference in status between the subject partner and the object partner. From these facts, it can be observed that a hierarchical difference similar to the concept of superiority and inferiority, not present in the early Confucian philosophy, has emerged. The hierarchy evident between men and women, husbands and wives reflects the influence of a patriarchal society, indicating a discrepancy with contemporary social values.

4. Conclusion

In the context of the Family Federation, the subject partner–object partner relationship aligns with the principles of Taoism and Confucianism, particularly incorporating the concepts of Yin and Yang. Specifically, in the context of gender relations, when representing the husband and wife, they are viewed as an immutable subject partner – object partner relationship, referred to as the original form. It is emphasized that there exists a hierarchy within the marital relationship. The hierarchy, if not maintained, can lead to confusion, extending beyond the declarative dimension into ethical principles that must be upheld, even carrying an implicit coercive nature. Thus, the relationships between men and women (spouses) in the Unification Thought reflect prevailing universal ideas today, aligning with gender equality. Therefore, the interpretation of the subject partner–object partner relationship concerning men and women, as well as husbands and wives, in Unification Thought needs to be reconsidered, potentially drawing from the foundations of early Yin-Yang philosophy or Taoist principles.

If the interpretation of men and women, as well as married couples, is defined in terms of a reciprocal subject partner–object partner relationship, many issues such as gender discrimination and misconceptions about fixed roles between spouses, leading to conflicts in marriages, could be alleviated. While the subject partner–object partner relationships within the Family Federation reflect certain patriarchal aspects, they also present fundamental ethical and spiritual principles that individuals should uphold in their contemporary lives. Particularly, the idea that subject partners and object partners must interact in a mutually harmonious relationship through reciprocal actions is undoubtedly a crucial keyword in today's society, along with concepts like 'coexistence' and 'win-win.'

References

1. Selected Sayings of Zhu Xi, Volume 65.
2. Selected Sayings of Zhu Xi
3. Genesis 1:1-5. In *The Bible* (The Bible Society of Korea,1988).
4. Yang, G.C. et al. *A Study of Yin-Yang and Five Elements Theory* (Shinji Books, 1993).
5. ibid, p.121.
6. Zhu, Xi. *Commentaries on the Book of Changes*
7. Yang, G.C., Cho, P.U., & Pung, W.R. et al., op.cit. p.120.
8. Appended Statements on the Trigrams. In *Book of Changes*
9. Cho, M.H. A Study on Changes in Perception of Seowangmo from the Perspective of Yin-Yang Philosophy. *Journal of Daesoon Thought 42*(0), 50 (2022).
10. Principle of Creation, ibid. p.28.
11. ibid, p.26-27.
12. Unification Thought Research Institute. *Essentials of Unification Thought* (Sung Hwa Publishing Co., 2018).
13. Choi, Y.J. Confucianism and Feminism: Exploring Their Intersection. *Journal of Confucian Studies and Culture 14*(0), 127 (2000).
14. Essentials of Unification Thought, ibid, pp.190-192.

Organized by

Hyojeong Academic Foundation

Hosted by

Hyojeong Academic Foundation
Sunhak Educational Foundation
Hyojeog Magnolia Global Medical Foundation

ISBN 979-11-981561-4-3(93060)