INTERNATIONAL CONFERENCE ON RESEARCH AND INNOVATION IN SUSTAINABLE CITIES (ICRISC 2022)

2022 Jurnal Kejuruteraan, Teknologi dan Sains Sosial
Vol. 8 Issue 1 (Special Issue – ICRISC2022)
International Conference on Research and Innovation in Sustainable Cities @ PUO

SWIMMING POOL WATER QUALITY: A CASE STUDY FOR CHLORINE ALTERNATIVE SWIMMING POOL

Joan Wang Yee Juen[1], Jason William Vitales[2], Nicole Audrey[3], Suhanida Ladah[4], and Mohd Khairul Ikhwan[5]

[1,2,3,4,5]Politeknik Kota Kinabalu, Malaysia
[1]joan@polikk.edu.my
[2]jason@polikk.edu.my

Abstract: Public swimming pool users are susceptible to infection by various disease-causing organisms. The most popular pool disinfection is the element chlorine, in the form of a chemical compound such as calcium hypochlorite (a solid) or sodium hypochlorite (a liquid). Chlorine however can accumulate in chlorine swimming pool water. There are several risks of health disorders that can arise from exposure including skin irritation, eye irritation, and respiratory disorders. Ultra-violet (UV) is considered some of the best technology on the market today for disinfecting swimming pools. This study aims to (1) compare the water quality of public swimming pools (chlorine) and Chlorine Alternative Swimming Pool (UV light plus organic Filter), (2) test the swimming pool water quality parameters, which are the (i) chlorine residue, (ii) turbidity, (iii) pH, (iv) temperature and (v) E-coli, and finally (3) to evaluate and analyse the water quality of chlorine alternative swimming pool. All parameters and standard values are subject to the latest Swimming Pool Water Quality Monitoring Guidelines issued by the Ministry of Health Malaysia. Based on the finding of the 5 parameters testing results, the water quality for the Theme Park1, Theme Park2 and the Chlorine Alternative Swimming Pool (CASP) (UV light plus Organic Filter) is in complying with the Water Quality Standard for the swimming pool issued by the Ministry of Health Malaysia. Further investigation is needed to ensure that CASP is sustainable and cost-effective before it could be implemented.

Keywords: *swimming pool; chlorine; disinfection: chlorine alternative; UV light*

1. Introduction

A public swimming pool and theme park are one of the recreational locations for people of all ages. However, swimming pool users are susceptible to infection by a diversity of disease-causing organisms. Bathers in public swimming pools are more likely to be exposed to disease-causing organisms compared to bathers in domestic or private pools because public pools are subjected to contamination from a wider community. Disease-causing organisms may be introduced from many sources but are mainly associated with bathers. These organisms may be brought into a pool from the bathers' skin, their saliva, urine and unintentional faecal discharge. These organisms may also be introduced from dust, bird droppings, make-up water as well as soil carried on bathers' feet.

Some of these disease-causing organisms live and may even grow in pool water unless the pool water is disinfected effectively and efficiently in a concontinuouslyry of Health Malaysia, 2017). Chlorine is a chemical that is often used as a disinfectant (Galal-Gorchev, 1996). Chlorine is available in solid, liquid, or generous forms. Chlorine is used to sterilise drinking water and disinfect swimming pools, as well as in the production of a variety of everyday items such as paper, textiles, medications, paints, and plastic, particularly PVC (Koch, 1946; Clark, 2019). Chlorine can accumulate in chlorine swimming pool water. There are several risks of health disorders that can arise from exposure including skin irritation, eye irritation, and respiratory disorders. Pool users often mistakenly think that the familiar smell in the pool is too much chlorine in the pool. The odour actually comes from the chloramines in the pool. It is an undesirable by-product of chemical oxidation in water. Airborne chloramines accelerate pool corrosion such as lifeguard stands, handrails, starting blocks, diving board rails, and stainless-steel deck equipment. It can also shorten your life (Psaroudis, Banker & Kershner, 2013).

The chlorine level should stay between 1.0 and 3.0 parts per million (ppm) to maintain a healthy pool. Pool operators, therefore, are subject to the Swimming Pool Water Quality Monitoring Guidelines issued by the Ministry of Health Malaysia (2017) to ensure that the water that comes into contact with bathers is in safe and pleasant condition. Over the years chemical disinfection has been used within the swimming pool environments, but with changing technology other safer disinfections are starting to take place. UV disinfection is much safer for both people swimming and the environment. According to Gobulukoglu, (2010, pp3) a Chief Scientist in Trojan Technologies Company, "*the UV light is claimed capable of reducing the level of chloramine in the water. A properly sized UV system could control chloramines; increases comfort and health for swimmers and staff; eliminates the need for dilution and super chlorination; reduces corrosion and, most importantly, protects against Cryptosporidium and Giardian*".

While UV technology for swimming pools has been used widely in other industries for many years, the emergence of UV for swimming pools in Malaysia has been more recent and uncommon. This study, therefore, aims to investigate the alternative pool disinfection system to replace the excessive use of chlorine in swimming pools in most theme parks swimming pool in Malaysia, specifically in Kota Kinabalu. UV pool disinfection systems harness the power of UV light to help pool owners reduce the use of chemicals and chlorine in their pools, making their pools safer, healthier and easier to maintain. UV pool disinfectants emit powerful germicidal rays that alter or destroy the DNA or RNA of target organisms such as algae, bacteria, viruses, cysts and protozoa. The highly concentrated electromagnetic energy also destroys organic matter, eliminating the formation of dangerous chlorine by-products (Gobulukoglu, 2010). A prototype consisting of a swimming pool, UV-light and organic filters (to replace sand filters) is then proposed. The objectives of the study are, (1) to compare the water quality of the public swimming pool (chlorine) and Alternative Chlorine Swimming Pool (UV light plus organic filter), (2) to test the swimming pool water quality parameters, which are the (i) chlorine residue, (ii) turbidity, (iii) pH, (iv) temperature and (v) E-coli and finally (3) to evaluate and analyse the water quality of alternative chlorine swimming pool.

2. Materials and Methods

Figure 1 shows the summarized flow chart of the research methodology. This study discusses in detail the four (4) important phases in the methodology and strategies used in completing this study:

1) Prototype Development
2) Filter Development
3) Data collection procedures
4) Data analyses techniques

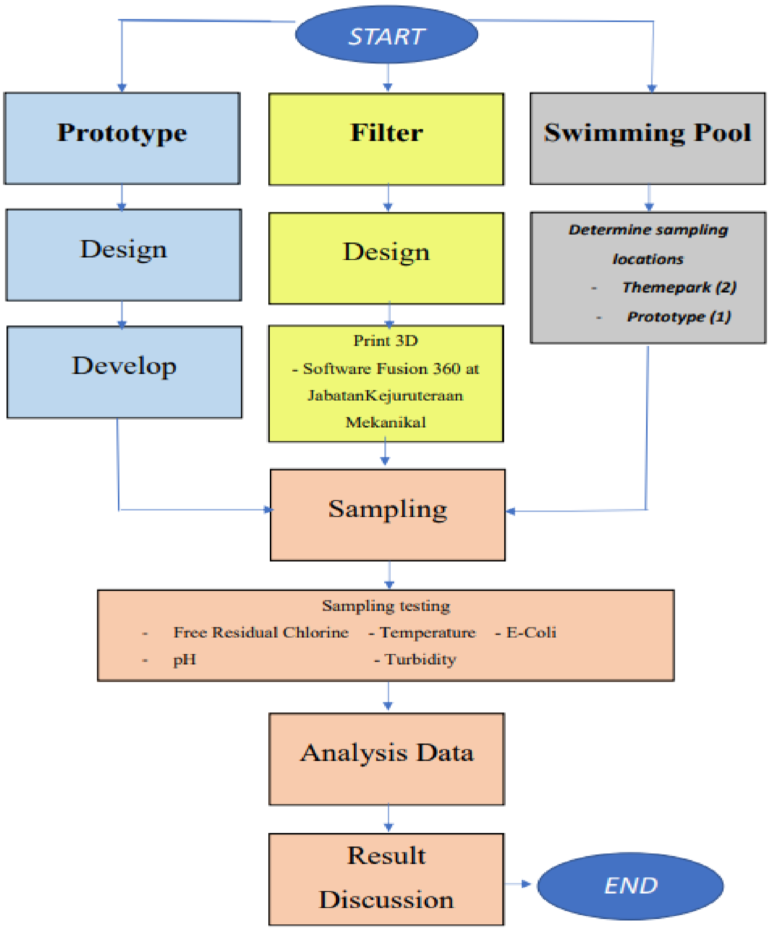

Figure 1: Research Methodology Flow Chart

[redacted]Chlorine Alternative Swimming Pool (CASP) Prototype Development

The ideal design for an alternative chlorine swimming pool (see Figure 2) consists of (1) a swimming pool, (2) a balance tank, (3) UV light and (4) an organic filter. The water from the main pipe or balance tank will go through the organic filter before being sanitized using UV light. Water that has been disinfected will be sent to the swimming pool and the cycle repeat continuously.

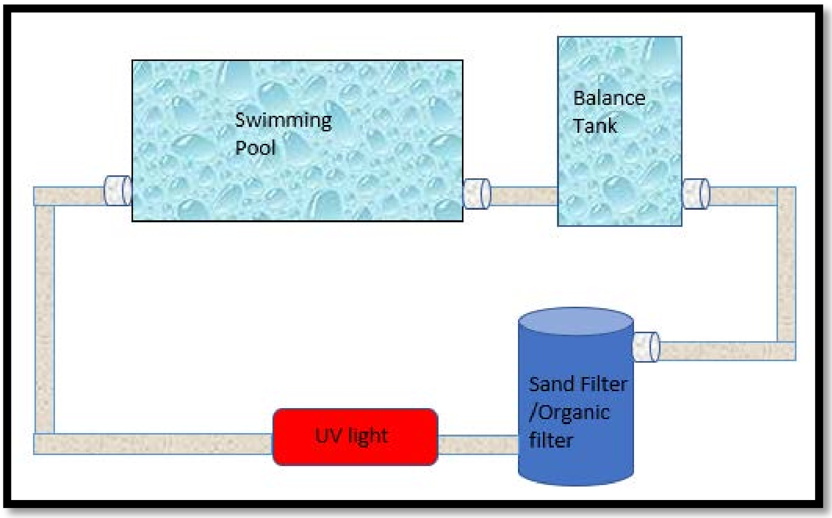

Figure 2: Chlorine Alternative Swimming Pool (CASP) Design

[redacted] Filter Development

The organic filter was adopted from H_2O Organic Purifier developed by Ismil (2021). Figure 3 shows the CASP prototype. The filter has six (6) layers of filters:

i. Fine Sand – retains fine sediments on the surface of the water
ii. Coarse Sand – has a high and strong density and filters solid impurities in water
iii. Rock – facilities filtered water through channels
iv. Charcoal – has a very large surface area and purifies water eliminates odours
v. Petola Coir– reducing ammonia nitrogen levels and water pH levels
vi. Filter-paper/Sponge – used as water filter passing through all the materials

Figure 3: Chlorine Alternative Swimming Pool (CASP) Prototype

[redacted] Pool Water Quality Standard

The acceptable standard values for parameters to be monitored are listed in Table 1. These standard values apply to treated pool waters. In this study, due to the limitation of resources and time constraints, there are only 5 parameters; (a) free residual chlorine, (b) pH, (c) turbidity, (d) temperature and (e) E-coli, to be tested given to these parameters have a direct or close association with the disinfection process (Ministry of Health Malaysia, 2017).

Table 1: Water Quality Standards Monitoring Guidelines
(Ministry of Health Malaysia, 2017)

No.	Parameters	Unit	Standard Values
1	Free residual chlorine	mg/I	0.5-3.0
2	pH	-	7.0-7.8
3	Turbidity	NTU	≤ 5.0
4	Temperature	°C	21.2-32.2
5	Escherichia coli (E.coli)	-	Absent in 100ml
6	Total Alkalinity (as CaCO3)	mg/I	80-200
7	Hardness (as CaCO3)	mg/I	75-250
8	Total Dissolved Solids	mg/I	≤ 1000
9	Cyanuric acid	mg/I	≤ 50
10	Nitrate (as NO3 – N)	mg/I	≤ 10

[redacted] Data Collection procedures and Data Analyses techniques

Theme Park 1, Theme Park 2, and Chlorine Alternative Swimming Pool (CASP) are the identified location for this study. Based on the size of the pool, there are two (2) positions (Point 1 and Point 2) taken not less than 2 meters away from the water inlet (chlorination location). While the water samples are taken at a depth of between 5 to 30 cm from the water surface and 50 cm from the pond's edge (Ministry of Health Malaysia, 2017). The UV light plus Organic Filter is the chlorine alternative disinfection system used in the third location namely, Chlorine Alternative Swimming Pool (CASP) proposed in this study. The total sample to be taken is five (5), and each sample will be tested for (i) free residual chlorine, (ii) pH, (iii) turbidity, (iv) temperature and (v) E-coli. For free residual chlorine samples taken are tested at Chemsain Consultant, Water Quality Laboratory, while the E-Coli and turbidity samples are tested at Jabatan Kimia Malaysia, Water Quality Laboratory, and the rest are tested in the field using portable testing equipment.

3. Results and Discussion

In this section, data or results of water quality testing of each location parameter are presented and compared to the Swimming Pool water quality standard.

a) Free Residual Chlorine

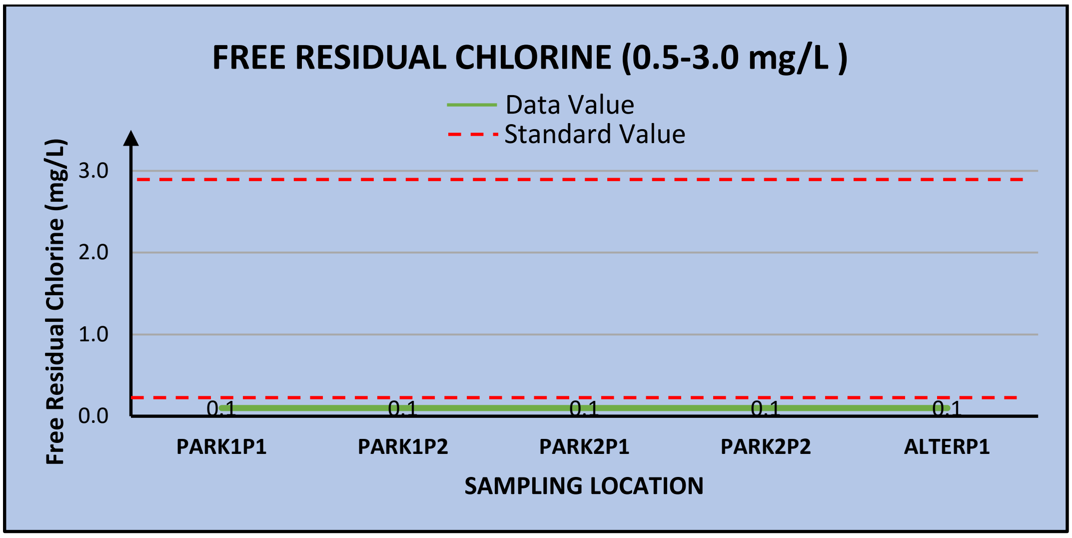

Figure 4: Free Residual Chlorine Data Result

The presence of free chlorine in the water is correlated with the absence of most disease-causing organisms, and thus is a measure of the potability of water. Based on the result obtained in Figure 4, chlorine residue is less than 0.1mg/l, which could indicate that the chlorine residual is a low level of chlorine remaining in water after its initial application. The low level of free chlorine residual in Theme Park 1 and Theme Park 2 swimming pools indicates that an insufficient amount of chlorine was added initially to the water to inactivate the bacteria and some viruses that cause diarrheal disease and to protect the water from recontamination during storage. As for the CASP (ALTERP1), the low chlorine residual level is due to no initial chlorine being added to the water tank.

b) pH

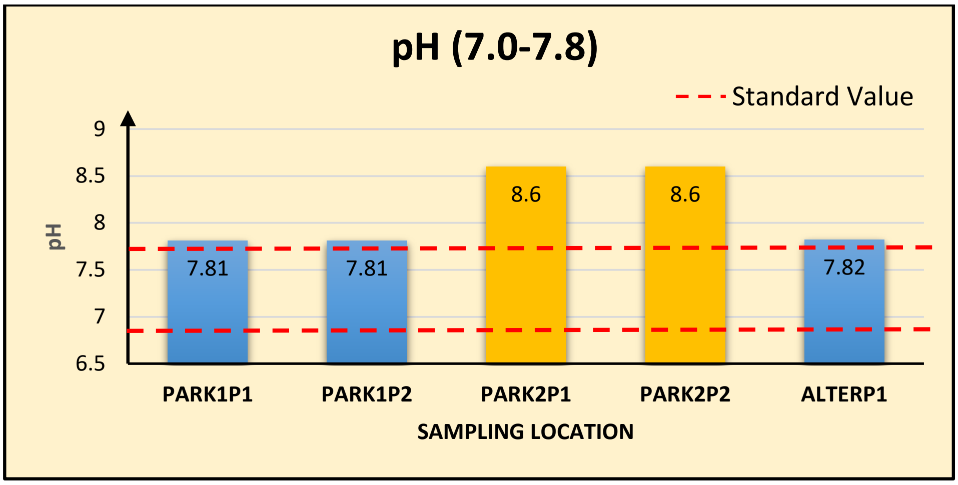

Figure 5: pH Data Result

Figure 5 shows that the pH level for PARK1P1 and ALTERPI are slightly higher by 0.01 than the allowable range for pH standards. However, the pH for PARK2P1 and PARK2P2 is higher by 0.8 than the allowable standard. pH above 8 can cause swimmers to have inflammation skin, while a pH less than 7 can cause inflammation of the swimmer's eyes. Several factors that can affect the pH level are chemical level in pool water, density number of swimmers, and rain density. In addition, when CO_2 off-gases due to splashing or aeration that agitates water causing bubbles to escape would also raise the pH of water.

c) Turbidity

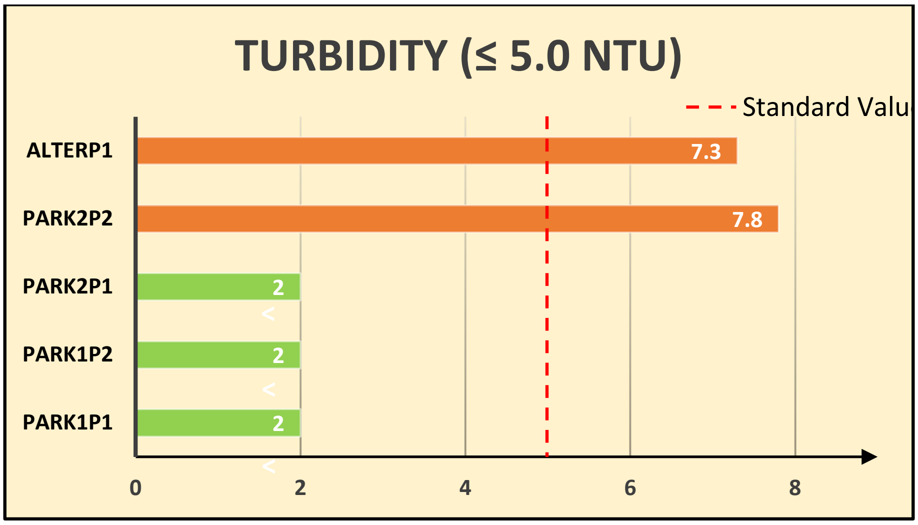

Figure 6: Turbidity Data Result

Based on Figure 6, both ALTERP1 and PARK2P2 exceeded the NTU for swimming pool turbidity standards. While PARK1P1, PARK1P2 and PARK2P1 are within the allowable NTU. As for the Turbidity, the turbidity result for Theme Park2 second point (7.8 NTU) and the CASP (7.3 NTU) is slightly higher than the allowed standard (≤5NTU) for turbidity. However, it could be caused by the water samples being taken too close to the surface of the pool and the depth of the water basin for CASP being too shallow.

d) Temperature

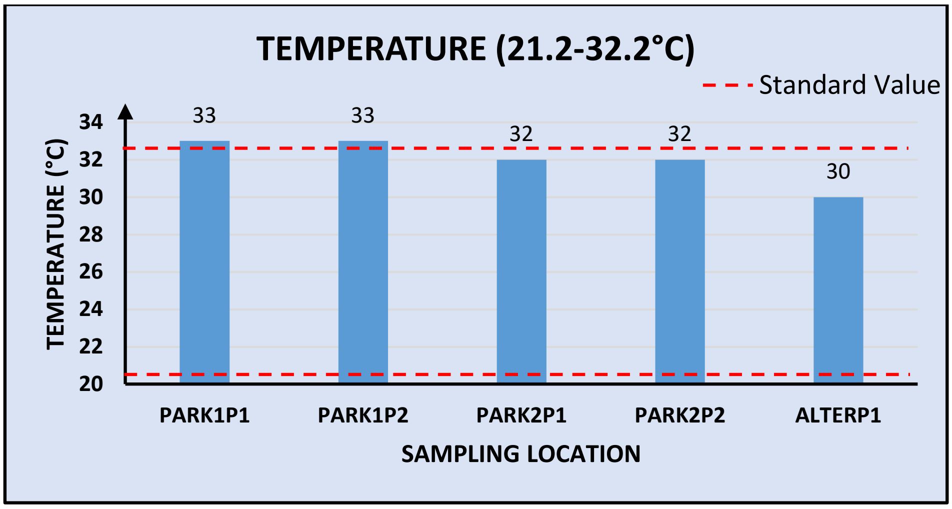

Figure 7: Temperature Data Result

Generally, the most common pool temperature for a residential pool used for leisure is between 21.2°C – 32.2°C. Figure 7 shows that all the swimming pool temperature is within the standard with PARK1P1 and PARK2P2 both recording slightly higher temperature.

e) E-Coli

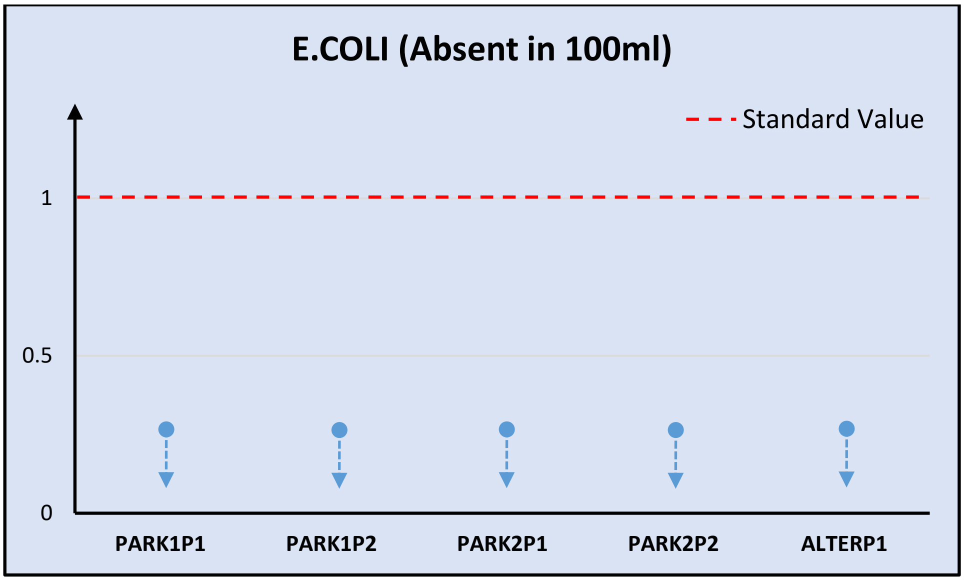

Figure 8: E-Coli Data Result

Figure 8 shows all the samples showing less than 1 (almost absent) E-coli in every 100ml of water sampling. According to the World Health Organization, a level of E. coli bacteria in the water that falls below 1 per 100 ml is considered low risk.

4. Conclusion

Table 2: The Summary of Water Quality Parameters

No	Parameter	PARK1P1	PARK1P2	PARK2P1	PARK2P2	ALTERP1
		Recorded Time				
		3.15 pm	3.15 pm	5.40 pm	5.40 pm	2.00 pm
1	Free Residual Chlorine	<0.1	<0.1	<0.1	<0.1	<0.1
2	pH	7.81	7.81	8.6	8.6	7.82
3	Turbidity	<2	<2	<2	7.8	7.3
4	Temperature	33°C	33°C	32°C	32°C	30°C
5	E-Coli	<1	<1	<1	<1	<1

Based on the finding of the 5 parameters discussed above, the water quality for the Theme Park1, Theme Park2 and the Chlorine Alternative Swimming Pool (CASP) (UV light plus Organic Filter) is partially complying with the Water Quality Standard for the swimming pool issued by the Ministry of Health Malaysia. There was not much difference in the water quality of the water Theme park's swimming pool and the CASP. All the water sampling for three identified locations has been tested and the result is summarized in Table 2. In conclusion, the

Chlorine Alternative Swimming Pool, CASP's water quality is considered safe for swimmers as it is free from microorganisms and residual chlorine. A further investigation needed to be conducted for commercial-size swimming pools, and to ensure that CASP is sustainable and cost-effective before it could be implemented.

Acknowledgements

We would like to express our gratitude to Jabatan Kesihatan Negeri Sabah (JKNS), Jabatan Kimia Malaysia, Negeri Sabah (JKM), Jabatan Kejuruteraan Mekanikal (JKM), Politeknik Kota Kinabalu and Chemsain Consultant Sdn. Bhd for their assistance and collaboration in generating data to complete the project.

References

Clark, J. (2019, June 5). The Manufacture of Chlorine. Retrieved from Chemistry LibreTexts.

Galal-Gorchev, H. (1996). Chlorine in Water Disinfection. *Pure and Applied Chemistry*, *68*(9), 1731-1735. https://doi.org/10.1351/pac199668091731

Gobulukoglu, I. (2010). Swimming Pools and Water Parks. UV Solution Magazine. https://www.americanairandwater.com/water/UV-Pools&WaterParks.pdf

Ismil, A.S. (2021). H_2O Organic Purifier. CEDIX 8, Jabatan Kejuruteraan Awam.

Koch, W. H. (1946). Facts about Chlorine. *Sewage Works Journal*, *18*(6), 1194–1198. http://www.jstor.org/stable/25030379

Ministry of Health Malaysia (2017). Swimming Pool Water Quality Standard and Monitoring Guidelines (for Public Pool Operators), Engineering Services Division, Ministry of Health Malaysia.

Psaroudis, J.C., Banker, R.S., and Kershner, K. (2013). An Insider's Guide to UV Treatment for Swimming Pools and Spray Pads – Regulations, Technologies, and Configurations. IUVA NEWS / Vol. 14 No. 3. https://uvsolutionsmag.com/stories/pdf/archives/150304PsaroudisEtAl_Article_2013.pdf