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DEVELOPMENT OF WATER TREATMENT SACHETS FROM THE SEEDS OF MORINGA OLEIFERA AND ACTIVATED CARBON

Hidayatul Aini Zakaria
School of Ocean Engineering, Universiti Malaysia Terengganu, 21030 Kuala Nerus,
Terengganu, Malaysia
hidayatul@umt.edu.my

Wan Salida Wan Mansor
School of Ocean Engineering, Universiti Malaysia Terengganu, 21030 Kuala Nerus,
Terengganu, Malaysia
wansalida@umt.edu.my

Norshazira Shahrin
School of Ocean Engineering, Universiti Malaysia Terengganu, 21030 Kuala Nerus,
Terengganu, Malaysia
shazirashaarin@gmail.com

Abstract

Water is a common chemical substance that is essential to all known forms of life. Purified water is essential for living a healthy life as such everyone should have access to it. Pollution of water bodies is a major health issue in many fast growing cities where population growth far exceeds the rate of development of wastewater collection and treatment infrastructure. Wastewater treatment is an essential process that removes impurities from the water, making the water safe for domestic usage as well as drinking. Conventional wastewater treatment includes the usage of *alum which would deteriorate health conditions with prolonged consumption. This research is focused on the development of water treatment sachets from the seeds of moringa oleifera and activated carbon. Characterization of the water treatment sachets was made by utilizing Brunauer, Emmett and Teller (BET), X-Ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR) and Turbidity Meter. BET analysis shows and isotherm linear graph which proved that the activated carbon have larger surface area, pore size and volume compared to seeds of Moringa Oleifera, this finding correlates well with existing literatures. This also indicates that the level of adsorption in activated carbon is higher and more capable of removing impurities in water compared to Moringa Oleifera, From XRD results, it is verified that both samples, activated carbon and seeds of Moringa Oleifera are amorphous in structure. FTIR analysis indicates that the functional group in both samples of activated carbon and seeds of Moringa Oleifera are similar with literatures. As the ratio of seeds of Moringa Oleifera increases, the removal become faster since it depends on the initial concentration. Turbidity Meter analysis showed that higher volume of Moringa Oleifera will increase the percentage of impurities removal. This study had proved that the combination of Moringa Oleifera and activated carbon is suitable for high turbidity water treatment and further study should be conducted before these water treatment sachets are available for public use.*

Keywords

Water Treatment, *Moringa Oleifera,* Activated Carbon, Natural Water Filter

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1. Introduction

Water is a source of life and considered as the most essential of natural resources for living things. 70% of earth consists of water and 98% of water is sea water but it is not safe for drinking due to high concentration of salt. Another 2% of the planet's water is fresh, meanwhile the 1.6 % is locked up in polar and glaciers. About 0.36 % of water is found underground in wells and also aquifers. Overcrowding in urban areas leads to serious water pollution. Water quality might be influenced by natural disasters including tsunamis, earthquakes, and volcanoes in a grand scale (Reddy, Seshaiah, Reddy, & Lee, 2012). One of the contributing factor in water pollution is heavy metals which imposes high toxicity to the environment which may steered to serious health problems to the public (Ngo & Tran, 2017). Drinking water may be affected due to disease carrying agents for example bacteria and viruses are carried into the surface and ground water which may lead to health hazards result (Kasper, Joshua W., Judith M., 2015). According to UNICEF, 783 million people worldwide usually in underdeveloped countries are without safe drinking water, and the World Health Organization estimates that lack of proper drinking water causes 1.6 million deaths each year from diarrheal and parasitic diseases.

Part of the problem is that many of these poor countries must import expensive chemicals to clarify the water, limiting the amount they can afford to produce. 3.4 million people, mostly children, died annually from water-related diseases. Most of these illnesses and deaths can be prevented through simple, inexpensive measures. For instance, trachoma remains the leading cause of preventable blindness, accounting for 146 million acute cases around the world. But the disease is almost unheard of in places where basic water supply, sanitation and hygiene prevail (World Health Organization Annual Report, 2015). The insufficiencies in safe water supply will give effect to health directly or indirectly. Transmission of most diseases in developing countries is through intake of contaminated water leaving behind serious health and economic effects. An example of water treatment technique used in underdeveloped country is filtration of water through aquifer sediments and soil. This results in safe drinking water supply of groundwater. However, the quality of groundwater may be effected by natural chemical components from geologic materials (Kasper, Joshua W., Judith M., 2015). Many researchers worldwide had tried to find the solution to produce clean drinking water with only the fraction of the cost of conventional water treatment system used in a modern country including utilizing material derived from the natural environment such as activated carbon and bio-coagulants.

Activated carbon has been found to possess great adsorption capability compared to other chemical and physical methods for purification process in terms of its ability for competently adsorbing a broad range of pollutants, fast adsorption kinetics and its easiness of design. (Hoseinzadeh Hesas, R., Arami-Niya, A., Wan Daud, W., & Sahu, 2013). Granular or powdered activated carbon is commonly used in developed countries for community water treatment. Activated carbons are carbonaceous materials that can be distinguished from elemental carbon by the oxidation of the carbon atoms found on the outer and inner surfaces. Adsorption by activated carbon known to be the most efficient way for removing heavy metals (Tan, Ahmad, & Hameed, 2008). Its efficiency as adsorbent for removing organic and inorganic pollutants has been verified and it can be produced in abundance at low cost from agriculture products such as coconut shell, rice husk and others (Kong et al., 2013). Activated carbon from coconut shell are well known for their adsorptive properties, very large internal surface area, relatively high hardness and low dust which makes it become attractive for water filtration applications. It also has predominantly pores in micro-pores size which match the size of contaminant molecules in drinking water and become effective in trapping it.

Moringa Oleifera known as multipurpose tree mainly used for food consumption, medicine and agricultural. *Moringa Oleifera* belongs to the family of *Moringaceae* which is one of the vegetables in Brassica order and there are 13 known types of this species but the two common species are *Moringa Oleifera* and *Moringa Stenopetala* (Khawaja Tahir, Mahmood Tahira & Ikram Ul, 2010). *Moringa Oleifera* was also recognized as one of the most effective natural coagulant compared to aluminium which is one of the conventional chemical coagulant (Bodlund, 2013). *Moringa Oleifera* were found to be beneficial in surface water treatment by lowering the settling time and the seeds are widely applicable in enhancing the quality of water in rural communities as it is highly abundant in nature (Redo-Sanchez, Laman, Schulkin, & Tongue, 2013). *Moringa Oleifera* has obvious advantage over chemical coagulant for water treatment because of its biological nature as well as safe for human consumption. Its seeds also have ability to kill bacteria and clarify water. Seeds of *Moringa Oleifera* contain a cationic polyelectrolyte that has been proved the efficiency as natural coagulant in water treatment and less expensive compared to the alum since it is available in rural communities in Nigeria (Zaku, Emmanuel, Tukur, & Kabir, 2015). Recent study had shown that the globulin and albumin, two protein components in *Moringa Oleifera* contributed the most as coagulation agent in surface water (Baptista et al., 2017). Researchers worldwide had tried to incorporate the usage of *Moringa Oleifera* as natural coagulant in modern waste water treatment, however there are not many studies that had proved the efficiency of *Moringa Oleifera* in large scale water purification (Ndabigengesere & Subba Narasiah, 1998). In this study, the main aim is to investigate the effectiveness in wastewater treatment using *Moringa Oleifera* as a potential bio-coagulant agent combined with activated carbon derived from coconut shells in the form of portable sachets. The combination of naturally derived bio-coagulant and activated carbon is hypothesized to effectively purify water as a safer and cheaper alternative compared to conventional wastewater treatment agent.

2. Experimental Method

Activated carbon for this project was purchased from Tan Meng Keong Sdn Bhd. The type of activated carbon used was Powdered Activated Carbon (PAC). The diameter of pore size was 17.2130 Å while the mesh size was 200. The total volume in pore was 2600.19 Å. Dried seeds of *Moringa Oleifera* were obtained from Moringa Oil Malaysia and the seeds were crushed using pestle and mortar into powder form. The seeds were then combined with powdered activated carbon in the form of water treatment sachet at various ratios to treat contaminated water to test effectiveness of the combination of the materials. Synthetic wastewater was prepared by mixing 10% of ooze ground with 90% of water.

The intrinsic structure and chemical composition of the sample was characterized by Brunauer, Emmett and Teller (BET) technique and Fourier Transform-Infrared Spectroscopy (FTIR) respectively. The effectiveness of the tablets were determined by turbidity meter. XRD analysis was performed by Rigaku MiniFlex II X-ray Diffractometer in order to study and determine the nature of the activated carbon and *Moringa Oleifera* samples whether the sample is amorphous, crystalline or both. Fourier Transform Infrared Spectroscopy (IRTracer-100 FTIR Spectrophotometer) analysis was conducted to determine the functional groups of activated carbon and *Moringa Oleifera*. Thermo Orion AQ3010 Turbidity Meter was utilized to detect the effectiveness of the water treatment sachets by optimizing optical scatter-detection techniques for fast, accurate turbidity measurements of water samples. Optoelectronic meters was utilized to measure turbidity by incorporating an artificial light source that emits a known intensity of light through a sample. The scattered light measured at an angle of 90° is then recorded on a photodetector. The photodetector must be centered at 90°, and cannot extend more than 30° from that center point. To minimize differences in light scatter measurements, the method states that the incident and scattered light cannot travel more than 10 cm from the light source to the photodetector (Rose, Kelly, Kemker, Fitch, & Card, 2016). This measurement principle is known as nephelometry. The results will be shown in NTU (Nephelometric Turbidity Unit). Figure 1 shows the principle of operation of a turbidity meter where the nephlometry measures the amount of light scattered at 90° angle from the transmitted light, where larger particles in highly turbid water will scattered more light which are translated as higher NTU reading.

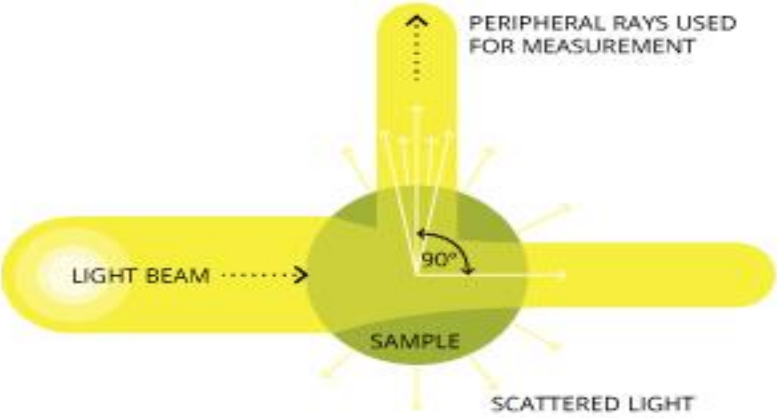

Figure 1: *The principle of operation of a turbidity meter (Rose et al., 2016)*

3. Results and Discussion

Figure 2 shows the isotherm linear plot of activated carbon obtained for the sample prepared under the optimum conditions. The pore structure characterization use nitrogen adsorption process which is a standard process to determine the porosity of the carbonaceous adsorbents. This isotherm linear plot indicate the highly porous structure of the activated carbon, where the effective surface area is 847.0627m²/g which correlates well with activated carbon of the same species from other study (Yang et al., 2010). The adsorption rate of an adsorbent depends on the size of the surface area and the number of pores of the adsorbent as the larger the surface area the higher the rate of adsorption. Through an activation process, the porosity of carbon has been developed and will create more porous structure. The adsorption and desorption pore diameter which is 17.2130 Å. The total volume in pores is <= 2,006.19 Å: 0.37008 cm³/g and total area in pores is >= 8.04 Å: 512.158 m²/g. The surface area of *Moringa Oleifera* as analysed by BET is 0.3965 m²/g (graph not shown in this paper), are remarkably smaller than that of activated carbon at 847.0627m²/g which corresponds to the fact that activated carbon is a porous carbonaceous material with large surface area compared to *Moringa Oleifera.*

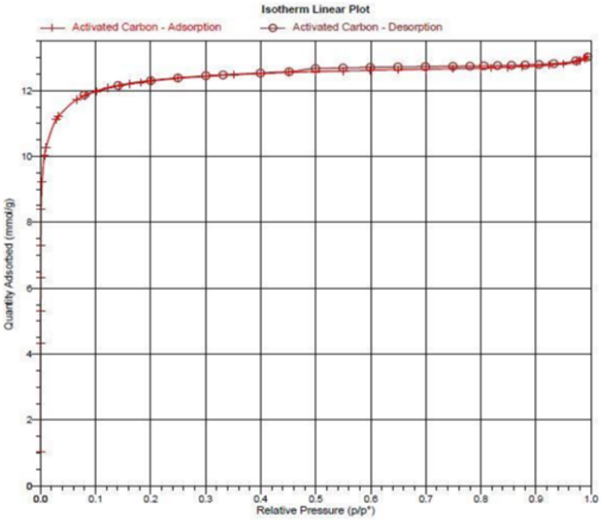

Figure 2: *Isotherm linear plot of activated carbon derived from coconut shells*

Figure 3(a) showed the XRD graph of the activated carbon from coconut shells. The graph shows that the activated carbon is amorphous. This can be explained by the rupture of multiple bonds C-C (the aromatic rings) and formations of group and functions on the surface. The graph showed that the broad peak is at 2θ = 24° and 45° revealed that the activated carbon is an amorphous structure correspond to 002 (carbon peak) and 001 plane. The crystallites are formed by two or more of these plates being stacked one above the other. Notable property for well-defined adsorbents such as activated carbon is the absence of sharp peaks which indicate it is a is a largely amorphous structure (Kennedy, Vijaya, Kayalvizhi, & Sekaran, 2007). Figure 3(b) showed the XRD graph of the seeds of *Moringa Oleifera*. The graph shows that the sample of seeds is amorphous. The broad peak shows at 2θ = 21° correspond to 001 indicated that seeds were amorphous in nature.

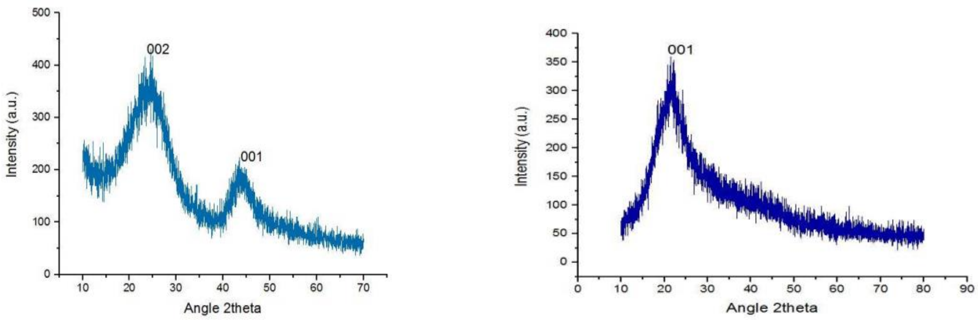

Figure 3: *XRD graph of (a) activated carbon from coconut shells and (b) Moringa Oleifera*

FTIR spectra of activated carbon and *Moringa Oleifera* used in this study correspond well with literature (data not shown in this paper). Figure 4 showed the FTIR spectrum mixture seeds of *Moringa Oleifera* and activated carbon, the broad and strong absorption peak at 2671.41cm^{-1} represent (O-H stretch) of acid group. At 2868.15cm^{-1} strong peak represent (C-H stretch) of alkane group and at 1639.49cm^{-1} peak represent (N-H bending) of amide group while the peak around 560-400cm^{-1} represents the skeletal modes of glucose pyranose ring.

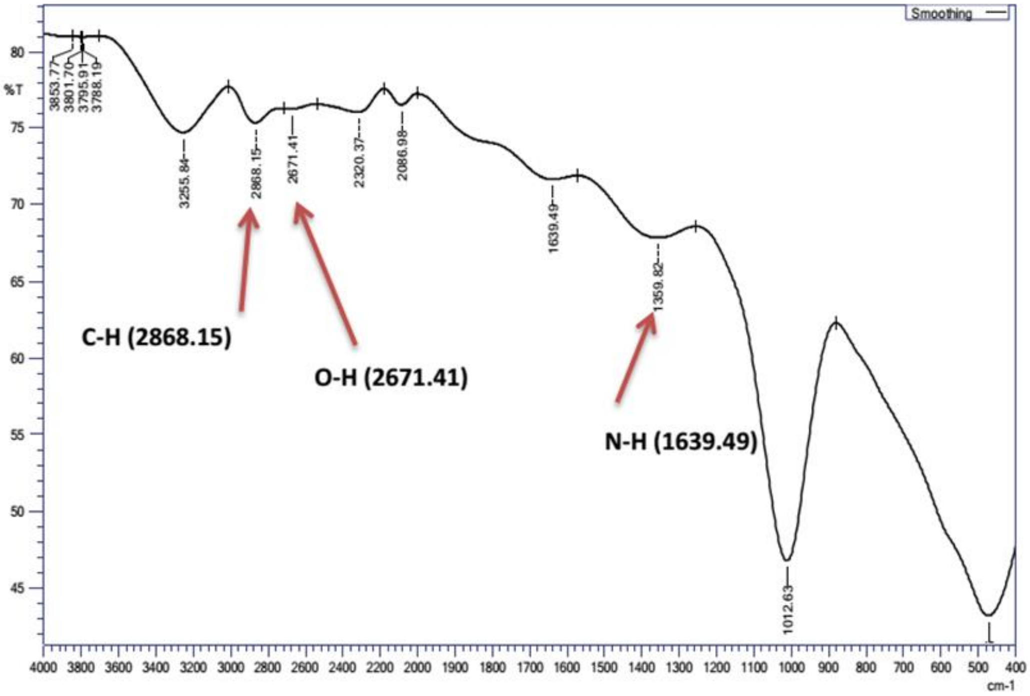

Figure 4: *FTIR spectrum of the mixture of activated carbon and Moringa Oleifera*

Turbidity is the degree to which light is scattered by particles suspended in a liquid or the amount of cloudiness in the water. This can vary from a river full of mud and silt where it would be impossible to see through the water (high turbidity), to a spring water which appears to be almost crystal clear (low turbidity). Turbidity is usually measured in nephelometric turbidity units (NTU) like used in this study or Jackson turbidity units (JTLJ), depending on the method used for measurement. Figure 5 shows the turbidity reading of activated carbon and seeds of Moringa Oleifera in contaminated water. The initial NTU reading of the synthetic waste water before treatment are 900 NTU for all sample ratios solutions. The reading was taken for three times and average was calculated as the final reading. The final NTU reading for sample (I) is

780NTU, for (II) is 644NTU, for (III) is 802 NTU, for (IV) is 756 NTU, for (V) is 762 NTU, for (VI) is 764 NTU and for (VII) is 500 NTU. This table showed that as the ratio of *Moringa Oleifera* increases led to higher contaminant removal in synthetic waste water.

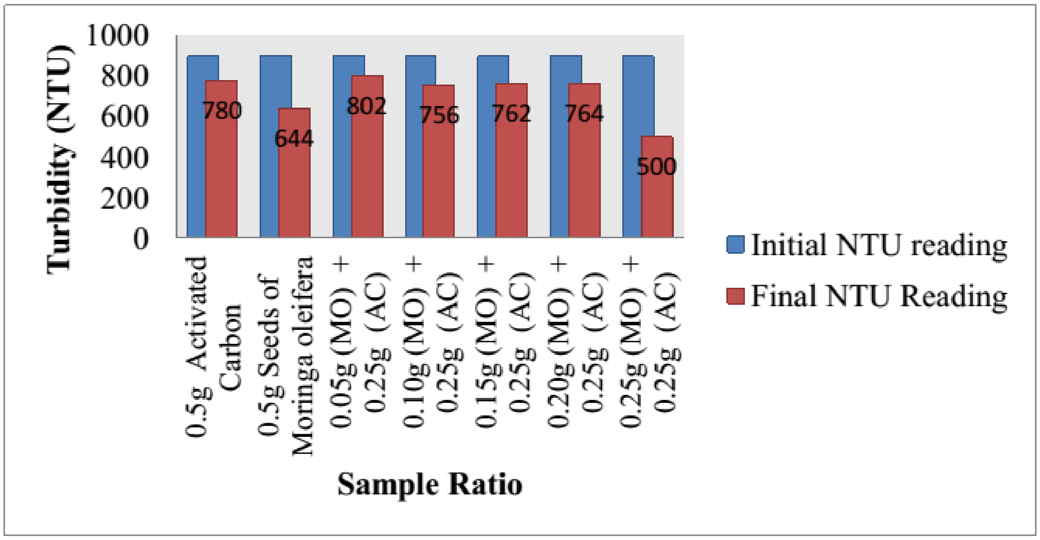

Figure 5: *Turbidity reading of activated carbon (AC) and seeds of Moringa Oleifera (MO) in contaminated water*

The percentage of removal as shown in Table 1 for sample (I) is 13.33%, for sample (II) is 28.44%. This shows that sample (II) have higher percentage of removal than sample (I) due to the different material used which are 0.5g activated carbon for sample (I) and 0.5g seeds of *Moringa Oleifera* for sample (II) .The efficiency of activated carbon was widely known in water treatment but it is also proven here in this study as well as in others (Suarez et al., 2003) that *Moringa Oleifera* works well in purifying turbid water especially highly turbid water. This statement was also proven by looking at the percentage of removal for sample ratio that mixed both constant mass of 0.25g activated carbon and manipulated ratio of seeds of *Moringa Oleifera* at 0.05g, 0.10g, 0.15g, 0.20g and 0.25g. Percentage of removal for sample (III) is 10.89%, for sample (IV) is 16.00%, for sample (V) is 15.33%, for sample (VI) is 15.33% and for sample (VII) is 44.44%. An increase in the ratio of seeds of *Moringa Oleifera* increases the percentage of removal and this was proven based on sample (VII). It was found in this study that *Moringa Oleifera* seed is a good coagulant in water treatment as it removes almost 50% of contaminant in highly turbid water.

Table 1: *Percentage of turbidity removal from various ratios of activated carbon and Moringa Oleifera*

Sample Ratio	Percentage of Turbidity Removal (%)
(I) 0.5g activated carbon	13.33
(II) 0.5g Seeds of *Moringa oleifera*	28.44
(III) 0.05g (MO) + 0.25g (AC)	10.89
(IV) 0.10g (MO) + 0.25g (AC)	16.00
(V) 0.15g (MO) + 0.25g (AC)	15.33
(VI) 0.20g (MO) + 0.25g (AC)	15.33
(VII) 0.25g (MO) + 0.25g (AC)	44.44

4. Conclusion

In this research, the natural material used to treat contaminated water are the seeds of *Moringa Oleifera* combined with activated carbon derived from coconut shells where these natural materials were mixed in several ratio in a sachet. Synthetic waste water was prepared by dissolving oozed ground with tap water at 10:90 (ml/ml) ratio. Activated carbon is commonly known as water treatment agent and adsorbent. The amount of adsorption of inorganics can be increases by impregnating the activated carbon with suitable chemicals as a catalyst of cleaning agent, this study had proved that the seeds of *Moringa Oleifera* may act as natural catalyst as substitute for chemical catalyst. Seeds of *Moringa Oleifera* also shows excellent ability as a coagulant agent especially in highly turbid water. Direct comparison with chemically derived water treatment agents including aluminium sulphate and ferric salt had shown that the use of *Moringa Oleifera* presents great advantages including low volume of residual sludge production, low toxicity and biodegradability (Kawamura, 1991; Madrona, G. S., Branco, I. G., Seolin, V. J., Filho, B. A. A., Fagundes-Klen, M. R., & Bergamasco, 2012).

In conclusion, the experimental method for activated carbon and *Moringa Oleifera* water treatment in the form of sachets has been developed through the preparation of sample at respective combination ratios of *Moringa Oleifera* and activated carbon. The water treatment sachets was then tested against synthetic waste water. Elements of *Moringa Oleifera* and activated carbon was characterized using FTIR,BET and XRD for its physical and chemical composition while the effectiveness of the water treatment sachets were characterized using Turbidity Meter. The combination ratio of 0.25g MO + 0.25g AC, shows the best result where it has achieved the lowest turbidity value at 500 NTU and the percentage of the removal of contaminants is 44.44%. Previous study has shown that the saline coagulant of *Moringa Oleifera* was able to remove up to 88.75% of turbidity in water by utilizing liquid form of coagulant (Baptista et al., 2015), whereas in this study we have managed to achieve 44.44% of contaminants removal using dried coagulant. In the near future it is recommended to use saline coagulant of *Moringa Oleifera* to improve the efficiency of water treatment system. The use of portable sachets containing *Moringa Oleifera* and activated carbon would be useful for consumers when in need of clean water as it is convenient and small in size. Rural areas that lack in water treatment facilities may benefit from the usage of these water treatment sachets to be able to obtain clean water for daily use several benefits for water treatment especially at rural areas and developing countries. For future study it is recommended to explore the potential of this combination of *Moringa Oleifera* and activated carbon in large scale water treatment.

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