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The Efficiency of (Bentonite) Organoclays in Removing Oils from Fast-food Effluents: A Systematic Review

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Abstract The effective removal of oil from water (oily-water) was achieved using the centuries' old method of activated carbon. In recent times, however, other methods using dispersants, absorbents, solidifiers, booms and skimmers were developed. These current methods of oil adsorption have varying levels of efficiency or are limited to specific oils. Recently research has highlighted the use of organoclays, a natural compound that has been proven to be both effective and efficient in oil removal from wastewaters. Organoclays have be noted to remove seven (7) times or more than its dry weight in oil making it more efficient than activated carbon. In this review, the researcher focused mainly on studies in which organoclays have been most effective. It is visually noted that the drains near fast food outlets have been observed to always contain oil contaminated wastewater, therefore these were the target zones in this review. The aim was to assess those approaches to ascertain the most effective design(s) for efficient oil removal from wastewater being released from fast food outlets.

Keywords Organoclays, Oil removal, Wastewater, Removing fast-foods oil residues from water

1. Introduction

Organoclays are classified as organically manufactured compounds made by modifying bentonite (natural clay) with quaternary amines (ammonium salt) [1]. The quaternary amines are surfactants, which have a water loving (hydrophilic) and oil loving (lipophilic) end [2]. Organically modified bentonite clays, or organoclays, have been in use for more than four (4) decades, mainly as commercial thickeners and flow-control additives in solvent-based systems (2003) [3].

The diagram below illustrates the development of the organoclay compound. It shows the group of smectite clay minerals composed of two silicate tetrahedral sheets with a central octahedral sheet, joined by common oxygen atoms to the leaves. The leaves are continuous in the directions of crystallographic axes (*imaginary lines within the crystal lattice*). The clay then treated with quaternary salts develops the ability to swell by adsorption of organic molecules, resulting in the organoclay.

Organoclays have been determined to have several benefits. They are stable to temperature fluctuations, do not decay readily and show good longevity performance. [5]. They can be tailored for the contaminant they are removing by modifying their hydrophilic and lipophilic groups. They have the ability to remove heavy metals such as lead, zinc, copper and nickel from water but more relevant to this study, they can remove at least 50-70% or more of their dry weight in oil, diesel fuel, polynuclear aromatic hydrocarbons (PNAH's) polychlorinated biphenyl (PCB's) and other chlorinated hydrocarbons from water. They are also able to remove seven (7) times the amount of oil as activated carbon [6].

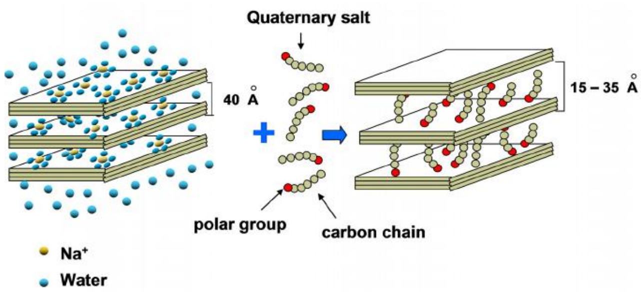

Figure 1. Diagram showing the development of an organoclay compound (*Source: (Cavalcanti Abreu, Carvalho & Motta, 2012)* [4])

Another significant benefit of organoclays is that they can be modified to become ecofriendly. A biodegradable organoclay (green organoclay) involving the application of organic modifiers with green properties such as betaine, ionic liquids (ILs), and amino acids/salts to the organoclay has been proposed [7].

Not all clays can be used to make organoclays. Bentonite clay is a lower taxonomic clay and found in clay mines around Guyana. Itis not mined in Guyana but is imported in large volumes annually. As seen in table 1 below

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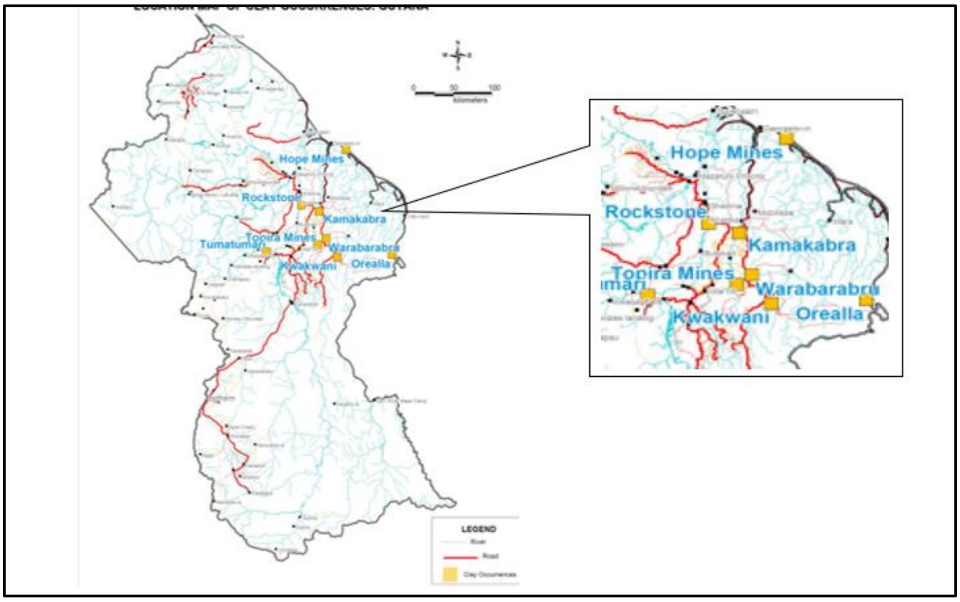

Figure 2. Map showing clay deposits in Guyana provided by Geology and Mines Commission. (*Source: Vieira (2014)* [8])

Table 1. Modified Table Showing Guyana's Importation Quantities of Bentonite Clay whether or not calcined in 2018

Reporter	Trade Flow	Product Code	Product Description	Year	Partner	Trade value	Quantity	Quantity Unit
Guyana	Import	250810	Clays (excluding expanded clays of heading no, 6806) bentonite, whether or not calcined.	2018	World	4563.28	6497790	kg
					Trinidad & Tobago	4532.64	6464910	
					United States	16.07	235.36	
					India	5.42	1955	
					China	5.36	13.21	
					Canada	3.80	6066	

Source: WITS (2021) [9]

Problems with Oil in waters

Oil in water can be present in four basic forms: free oil, mechanically emulsified oil, chemically emulsified oil, and dissolved oil. Most of the oil and grease found in restaurant waste is free oil, which will rise to the surface of the water. However, the chemically emulsified oil may be a significant portion of the total grease in food service wastewater since it is carried through the septic system to the leaching facility. According to BCDHE (2021) [10], this is the one that causes the most concern since it can become mixed with shared water systems.

In 2014, Guyana Water Incorporated (GWI) released a statement saying, "The company continues to experience numerous reports of overflowing sewerage which has resulted from sewer pipes becoming clogged due to coagulated fats and oils used for food preparation by restaurants and hotels" [11]. This statement was released after GWI appealed to restaurant owners to desist from releasing fat and oil into the water systems just five (5) months prior as stated by Fredericks, the Human Resources Officer.

BCDHE [10] stated that the best strategy for dealing with chemically emulsified oil in restaurants wastewater seem to be preventing it from becoming emulsified in the first place.

O'Shields when reporting on Fats, Oils and Grease (FOG) residue in the environment, stated "that anything poured down a drain or a gutter system, will mix with shared waters in the environment and this is an illicit (illegal) discharge", Environmental Protection Agency (EPA) [12]. In the case of flooding, cross mixing of these waste waters can contribute to more long-term harm than good.

Sariyer Council [13] posited that twenty-five percent (25%) of water pollution is caused by waste oil released into the environment usually because persons believe it can be poured down sinks, toilets orbins (where it eventually seeps out) or they are under the illusion that throwing hot water behind the oil removes it from the system. [3] In these cases, the hot water cools and the oil become solidified, accumulates and eventually narrows the pipe's internal system [15].

Chu & Hsu, in their research on polluting waste from Chinese restaurants, stated that "as more food is prepared in larger restaurants, the increased water usage is not capable of diluting the mass loading of chemical oxygen demand (COD) and oil/grease that comes from their food processing" [14].

Mills (2010) stated that there are approximately two hundred thousand (200,000) sewer blockages throughout the UK every year, with an estimated seventy-five percent (75%) of those pipes being blocked because of FOG [16]. Consequently, residues are most prevalent around the world during festivities and celebrations like Christmas and Thanksgiving, where more than sixty percent (60%) of FOG waste goes directly into the drainage systems [17]. Therefore, oil residue in the environment is a major concern that has yet to be resolved.

Oil residue, when immersed into aquatic ecosystems, forms a thin film on the surface of the water, thus causing several ecological impacts such as decreased dissolved oxygen in the waterbody and a decline in sunlight penetration into the waterways for photosynthesis of phytoplankton, on which aquatic species depend for food National Research Council, DC [18].

These organic toxic waste oil and grease (O&G)) are threatening to aquatic ecosystems and have the potential of causing mutagenic and carcinogenic effects [19] in humans and organisms. Another point often overlooked is the unbearable stench that FOG waste emanates [20]. These are caused from the increases in growth of bacteria, viruses, and pathogens which may ultimately result in disease outbreaks becoming more of a public health crisis [15].

BBC (2017) reported in Belfast, Ireland, that "these fat blockages can not only result in out-of-sewer flooding, but odour problems and the risk of rat infestations both near and beyond your premises [21]. Fat blockage caused the city over five (5) million pounds in repairs and weeks lost due to business closure. Tejpar (2003) stated that the UK spends over twenty (20) million dollars annually to clean up and reduce the risk of sewer flooding because of FOG, hence the need to reduce FOG outflow into the environment [22].

The picture below in figure 3 shows an image taken in NewYork City depicting the damage done to the pipes from FOG from fast food outlines. This clearly shows the solification of the FOG overtime when it gets into the pipelines [23].

Figure 3. FOG Residue Clogging Local Drains Connected to Sewers (*Source: Unknown (2021))* [24])

El-Gawad (2014) stated that there are many conventional techniques currently being used for oil and grease removal, especially since their efficiencies are very low [25]. These conventional methods include dispersants, absorbents, solidifiers, booms, and oil and grease skimmers. Therefore, the exploration of a substitute with higher efficiency levels of oil removal needs to be explored.

Table 2 was taken from a Wisconsin study which showed that only a small percentage of grease residue was removed by using conventional techniques such as grease trap. Clear indication of very low levels of efficiency. It must be noted that a Zabel Filter was used in this design to improve on the regular grease trap to improve its efficiency in grease removal since it was observed to be low. However, it was stated that if the Zabel filter was not serviced regularly the process of oil removal would slow or stop completely. Efficiency of oil removal was noted in table 2 provided below.

Table 2. Modified table illustrating varying food outlets and the estimated amount of grease being removed by grease traps being used

Restaurant Type (with 1,000-gal grease rap)	Grease Influent (mg/l)	Grease effluent (mg/l)	Approximate Percentage removal (%)
Fried Chicken	120-6500	56-110	2-47
Chinese	76-1300	34-120	9-44
Mexican	96-1040	19-110	10-20
Country/Club	130-706	22-94	13-17
Table Zabel filter effluent results, information supplied by manufacturer in the Wisconsin study/ Table has been modified to include percentages			

Source: (BCDHE, 2021) [10]

Another major challenge is that there are limited studies that have assessed the full potential of organoclays. Thus, organoclays have not been widely used by industries since most testing has been conducted in laboratory settings.

This review article seeks to provide a clear outline of the effectiveness and efficiency of using organoclays in removing oil from waste water compared to more conventional methods like activated carbon.

2. Methodology

The research strategy applied in this review on organoclays consisted of literature searches in Google scholarly, Z-books, JSTOR, SCOPUS and EBSCO archives through the University of Guyana student access link. These platforms provided access to thousands of scholarly pieces of literature from 2000 to 2020. However, the use of organoclay studies were limited in number, thus, a more thematic approach was adopted.

This review provides highlights of research studies that have been published on the efficiency and effectiveness of organoclays in removing oil from wastewater using a variety of methods and use of organoclays in varying forms were selected. The studies reviewed were all linked to Alther's theory, which stemmed from Jordon's work in the 1940s cited by Chaiko (2006) in their article on Preparation of

Organoclays [26]. With this focus, the review was narrowed to five (5) methods using organoclay where they have been deemed efficient and effective to assess and make inferences regarding the best possible method(s) for removing oils from waterbodies polluted mainly from fast food outlets.

No studies on the use of organoclays to remove oil from wastewaters were found in Guyana, thus all studies examined were from international sources. However, since there seemed to be a commonality in oil residue in drains where fast food industries are present, regardless of country, these methods would find universal application.

These database searches were neither temporal nor chronological. Articles that matched the theme were pre-screened based on their abstracts. In some cases, introductions, methods and conclusions were reviewed in order to guide the final selection for this systematic review. It must be noted however, that studies retrieved on organoclays were based mainly from chemists' standpoints while those on restaurant pollution of oils were viewed from a biologist's viewpoint. Therefore, connections were made to ensure the inclusivity from all angles.

The articles selected were then reviewed and the most significant data relating to the theme were extracted for use in this study. Emphasis was placed on the outcomes of the studies and the variability in the methods and their successes or failures. The data was then analyzed and subsequently used to present this review using a thematic approach before an overall conclusion was drawn and recommendations made for future research.

3. Evaluating Methods to Remove Oil Using Organoclays

1) Powdered bentonite organoclay

Powdered bentonite organoclay has been assessed in several studies to determine its efficiency in oil removal. These studies were based on the Freundlich's model, which is premised on dispersing powdered bentonite organoclay on the surface of oil-based wastewater to observe its oil adsorption tendencies. One such study was conducted by Okiel, Mohamed & El-Kady (2011) in Egypt [27].

However, these studies mainly compared the Lagergren model of 1989 that was remodeled by Alther in 1995, which all yielded the same outcome of 70-90% oil adsorption. In one study by Viraraghavan & Moazed [28] based in Estevan Saskatchewan, Canada, the method by Alther (1995), the Lagergren's model, was compared using a different method called the Freundlich model, to determine the best efficiency model for oil removal. While the article provided evidence that organoclays were effective in oil removal, it did not provide a kinetic analysis nor did it examine the applicability of absorption isomers to oil removal by organoclays, thus the true efficiency of the organoclays were not determined.

Viraraghavan & Moazed [28] used four types of oils: mineral oil, two cutting oils (Kutwells-45 and Valcool) and refinery oil with concentrations ranging from 26 mg/L to 381 mg/L, to investigate the potential of powdered bentonite organoclay on oil removal. The study compared oil removal from synthetic and actual oil in water emulsions, to evaluate the adsorption capacity. The powdered organoclay was dispersed into the wastewaters in batches using a two-phase system. The first phase lasted between 15 to 30 minutes, when rapid absorption occurred. This accounted for about 70 to 99% of the oil being removed from the waterbody during this phase. The second phase was much slower with very little oil being removed in this phase. Most of the oil adsorption occurred during the first phase with an overall equilibrium time of one hour.

The report further stated that both the Lagergren's model and the Freundlich model used showed a 95% statistical confidence level to be able to describe the absorption kinetics for the mineral oils and the two cutting oils but no kinetic analysis was done. This indicated that the absorption capacities were high for the cutting oils, but even higher in the Freundlich's model than in the Lagergren's model. The contrary occurred with the refinery oil which had very low adsorption values of approximately thirty-seven percent (37%). Viraraghavan & Moazed [28]) concluded that because the refinery oil was already pre-treated and were highly stable, then the significant levels of adsorption were very low and correlation non-existent.

While the article provided evidence that organoclays were effective in oil removal, it did not provide a kinetic analysis nor did it examine the applicability of absorption isomers to oil removal by organoclays, thus the true efficiency of the organoclays were not determined.

The bentonite organoclay was deemed efficient and the batch system applied was found to be suitable for treating wastewater in small volumes. It was also stated that organoclays would have the ability to remove up to 100% of oil from oil in water emulsions, but it is contingent upon the equilibrium time of contact. Therefore, the authors concluded that Freundlich's model provided the best isomers in this study for absorption of oils, since the oil removal capacity was greater than that discovered by Alther's study in 1995.

Another advantage discovered in the Alther's study was that bentonite organoclays had the ability to also remove heavy metals such as lead, copper and nickel from its solvent. Other oil removal methods did not possess this capability. However, the study did not indicate to what degree heavy metals were removed in this regard.

In a follow-up study Kshash, [29 and a previous study by Watson [30], similar results were observed where it showed organoclays being 70-90% oil adsorption capacities, but it emphasized the fact that the quantity of quaternary amine that was used in preparation of organoclay had very significant effects on the removal of oil from wastewater. In this regard, it was the weight ratio of quaternary amine in the organoclay increased, the oil adsorption capacities also increased. Kshash [29] also found that the rate of flow of the substance through the organoclay being used was also important, since the faster the speed of the mixers, the thinner the oil, thus filtration occurred faster [27] [28].

The same conclusion from Ksash's study was stated in research done by Chidi, Nnanna & Ifedi [31]]. In their study, the bentonite used was mined in Nigeria and the phenol used in the research was obtained from Guangdong, China with chemical formula C_6H_6O. In this research they also concluded that "by increasing the time of agitation of the modified bentonite in the phenol solution it would increase the adsorptive properties of the organoclay".

Chidi, Nnanna & Ifedi [31], study went a little further and addressed the kinetic analysis that was lacking in Viraraghavan & Moazed's (2005) research [28]. These researchers, Chidi, Nnanna & Ifedi [31], stated that the adsorption process fit well with the pseudo second-order kinetic model equation and confirmed that weak chemical interactions controlled the rate adsorption step of phenol, which simply meant that the rate of adsorption was highly dependent on the initial concentration of phenol solution.

These studies have all concluded that bentonite organoclay is effective in removing oil from water with an efficiency ratio being above 70% in every instance. Agitation of the solution through the mixture, multiple passes and the weight ratio of quaternary amine in the organoclay were all major contributing factors.

The diagram in Figure 4 illustrates how the removal of contaminants from waste water would appear with their bonding structure. This study was done in Iran where low-cost Iranian bentonite was modified and used to adsorb the removal of pollutants with physiochemical properties like phenanthrene (PHE) and copper ions (Cu^{2+}), and so on, from both simulated and real wastewaters.

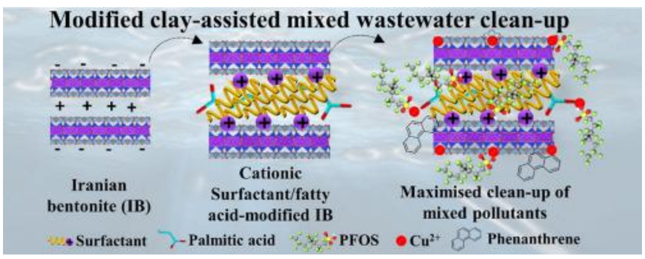

Figure 4. Modified clay structure being mixed with waste water to show removal of pollutants (*Source: (Khodabakhshloo, Biswas, Moore, Du & Naidu,2021, volume 800, ISSN 0169-1317)* [32])

2) Compacted organoclay through pipes and Freundlich isotherms

In another study by Moazed & Vlraraghavan earlier in 1999, investigated using another method, the Thomas method to determine if the thickness and rate of flow of wastewater through the organoclay compound could ultimately influence the adsorption capacity of the organoclay [33]; this was termed the mass balance analysis. This model was linked to a Morris and Weber model which deals with correlation and comparison of intraparticle diffusion.

The Thomas method is the use of compacted organoclay involved in pumping wastewater through pipes at different flow rates to pass through compacted organoclay. This method used compacted bentonite organoclay (anthracite) mixture in granular form in long cast acrylic pipes in varying diameters, depths and at various timings.

Moazed & Vlraraghavan [33] found that the depth and rate of flow influenced the efficiency level of absorption. This was consistent with other studies such as Tang & Gao [34], Faisal [35] and Islam [36]), although the methods varied. In this research, long acrylic cast column pipes packed with bentonite organoclay with depths ranging from 450 mm to 1,200 mm depth/thickness, with 19 mm diameter were used. Rates ranging from four flow rates of 3 ml/minute, 6 ml/minute, 9 ml/minute, and 12 ml/minute (0.3, 0.5, 0.8 and 1.0 gpm/ft^2, respectively) were used to determine the most efficient. The results confirmed that the depth of the organoclay bed had a direct effect on the oil removal efficiency, since the thicker the depth, the higher the concentration of oils removed. As the flow rate increased, the efficiency level of removal decreased, as expressed by a 50% to 70% efficiency.

Unlike the kinetic method analysis in which the mineral oil and the two (2) cutting oils showed greater absorption capacities, the opposite was observed in this study. The refinery oil had the highest absorption capacity after eight hours or more, with approximately ninety percent (90%) absorption capacity in all three trials. Based on these findings, it was determined that this method is best suited in column filtration systems and in cases where the water can pass through more than one system of pipes. In such a circumstance, this method will yield a one hundred percent (100%) result in the removal of oil residue before being released through the pipes, into the environment.

All these cited conclusions were substantiated by Vianna [37], in that the adsorption of the oil was more evident when the organoclay and the wastewater were mixed, instead of when the organoclay compound was added to the water and left to settle to adsorb the oil residue.

Vianna's (2014) [37] research was more focused on Freundlich isotherms absorption, comparing bentonite clay from Brazil to bentonite clay from Wyoming to assess their effectiveness in phenol adsorption. It was concluded that the Brazilian clay was more efficient than the Wyoming clay in removal of the petroleum compounds from the water, however no reason given to allude to this. Vianna [37] further stated that the Freundlich isotherms were found to be very effective since they could be used to control pollution from petroleum contaminated waters by filtering out most if not all of the residue and this was evident when it was mixed with the wastewater, rather than being left to amalgamate on the surface. The study concluded that Freundlich isotherms would be best suited to be liners for waste disposal reservoirs due to its effectiveness in phenol absorption.

The schematic sketch below in Figure 5 shows the connections from restaurants to sewer systems. This illustration shows how the image in Figure 2 becomes a reality.

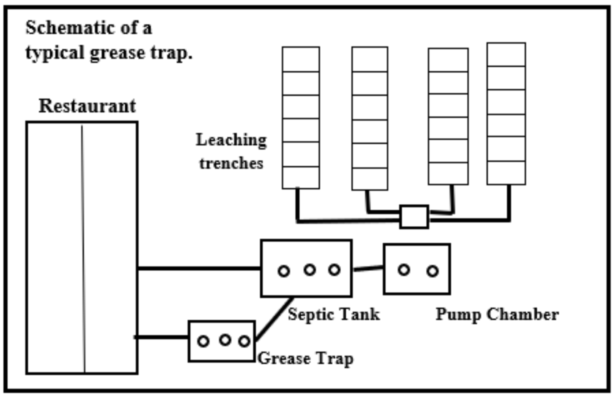

Figure 5. Diagram of schematic view of a typical grease trap set up and its connection to sewer tanks (*Source: (BCDHE, 2021)* [10])

3) Short and Long Chain Organoclays

Long chains and short-chain organoclays were compared to assess their adsorption techniques for oil, as this would measure their kinetic behaviour of organoclays. A study conducted by Salehi, Mowla & Karimi, [38] compared the adsorption capacity and adsorption kinetic behaviour of two commercial long chain organoclays and two modified short chain organoclays for removing oils from saline waters. For this research, the Cloisites were supplied from the USA, local clay collected at Jahrom mine, Fars Province (south of Iran), and the crude oil was selected from Gachsaran, oil field in the south of Iran. This study focused on the removal of crude oil released from oil fields in the south of Iran. The study also used a batch system for applying the organoclays to the surface of the water, while recording their adsorption abilities in terms of success or degree of effectiveness.

They used bentonite organoclays, which were modified to form Cloisite 15A and Cloisite 30B long chain organoclays, and two organically modified clays with tetramethylammonium chloride (TMA-clay) as short chain organoclays. This was so because it was stated that clay minerals, montmorillonites (MMT), have become important due to their high cation exchange capacity (CEC), high surface area, and strong absorption capacities compared to that of activated carbon when used in the removal of oils. They have also been deemed to be more economical.

This research by Salehi, Mowla & Karimi, [38] considered the pH, temperature, ionization and absorption capacities of the organoclays in order to determine whether these attributes/properties would affect the efficiency of adsorption by the clays. The results showed that the dependency on pH was low although optimum pH values for oil adsorption were observed within 25-30 minutes and 50-55 minutes for long and short chain organoclays, respectively. This was termed Freundlich isotherm.

Findings of studies conducted by other scientists, Katz, Bowman & Sullivan [39] in the USA, also corroborate this outcome, stating that the long chain organoclays were more effective in removing oils from saline waters by at least of 95%. This was reflective of more than two (2) times that of the short chain organoclays in situations in which oil concentrations were greater. In other places where the concentration of oil on the surface was thinly spread or low, the short chain organoclays showed greater adsorption efficiency of oil removal there. Thus, when comparing the absorption capacities in terms of percentage oil removal, the short chain organoclay had approximately 70%, while the long chain showed 95% - 99% oil removal. These findings confirmed that in those waterbodies where there is an intrusion of saline water into nearby drainage outlets or in flood prone areas, the techniques that require splitting the chains of the organoclay could be effective in breaking down oil residues.

Carmody, Frost, Xi & Kokot [40] stated that two long chain organoclay complexes have more interaction with the hydrocarbon molecules, thus making them better absorption complexes in the removal of oils or waste from the environment.

The diagram in figure 6 shows the bonding mechanism with organoclay, the surface and the contaminant. The adsorption ability that would take place on the surface of the clay as clearly depicted on the right.

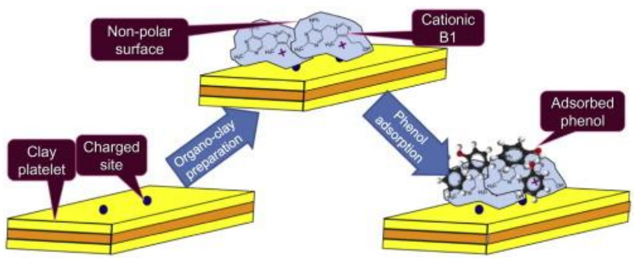

Figure 6. Showing organoclay preparation and its non-polar and cationic charge. (*Source: (Moshe & Rytwo, 2018, pg. 50-56)* [41])

4) One size approach for oil removal

Regarding studies about oils and organoclays, Alther [1] emphasized limitations in both industry and academic research relating to oil removal and the use of organoclays. He explored the possibility of organoclay’s efficiency regarding whether there was a general model (one size fits all model) pertaining to organoclays removing all or any type of oil. The study explored fifty (50) different oils that were broken down into the following five (5) categories: 1) Petroleum derivatives, 2) Mineral oils, 3) Vegetable oils, 4) Animal/fish oils and 5) Synthetic/essential oils. Samples were done in batches and not released directly into the environment. However, it was discovered during the experiment that because the organoclays were in a powdered form, they tended to clump/amalgamate. Due to this, it was relatively easy to apply the organoclays into the environment, observe the adsorption process and then remove the amalgamated substance without it becoming converted into a pollutant.

Younker & Walsh (2015) [42], in their study stated that because the organoclay adsorption occurred by hydrophobic interactions (lacking water), caused it not to swell and become a pollutant.

This research did not find a one size fits all approach for oil removal using organoclays, but rather organoclays were most effective by being up to seven (7) times more efficient than the activated carbon or any other conventional method at removing the oils from water, as was also stated by Islam [36].

Unfortunately, crude oils were not well removed. It was theorized that this occurred as a result of the added fatty acids, which reduced the ability of the organoclay to work effectively given its chemical structure/properties. The lubricating oils also posed a challenge, as it stuck to the walls of the containers, thus only those on the surface could have been accounted for during the efficiency testing. Alther then concluded that true efficiency value was not clearly determined after this research.

Although organoclays removed all surfactants as effectively as carbon, Alther concluded that one standard organoclay does not fit all applications effectively, since the cationic organoclays were far more effective in oil removal than that of its anionic counterparts.

Figure 7 below showing oil contaminant being mixed with organoclay and other conventional oil removing competitors to compare efficency of oil adsorption. Note this study did not specify what competitors specifically A and B were, rather just stated they were conventional methods and that acitvated carbon was used.

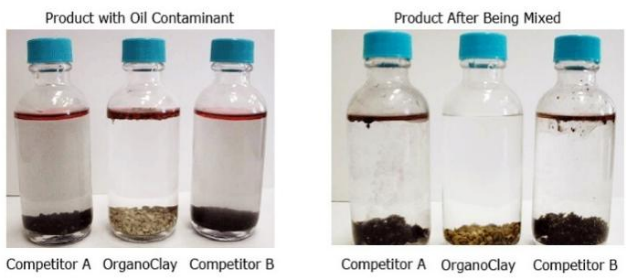

Figure 7. Illustration of oil and grease residues being removed with the use of organoclay and two compeitors from conventional methods. (*Source: (Ecologix, 2018)* [43])

4. Conclusions

Of the four methods reviewed, it was observed that there was no one-size-fits-all approach for FOG waste removal. However, the effectiveness of the use of the organoclay compounds in removing or adsorbing oils from waterbodies was consistent regardless of the way it was used, its kineticist or its chain properties. What varied was its efficiency in the varying forms of adsorption and the weight ratio of quaternary amine in the organoclay and if agitation was being used were all major contributing factors.

As was initially presented in the research, the short chain organoclays worked well on surface oil that was thinly spread. Therefore, applying bentonite organoclay in a powdered form on the surface of the water and skimming the amalgamated organoclay and FOG compound from the surface can be a measure implemented at the end of each working week or working day, depending on the level of waste being produced by that fast food outlet.

FOG should not be thrown down the drains, however, regardless of the steps taken in commercial restaurant settings, some amounts of oil or fat will pass through the system. Thus, organoclay filters attached directly to the drainage pipes in the sinks with several rotating systems of connecting pipes would be very beneficial. This would significantly reduce levels of oil residue being released into the environment or connecting sewer systems. In all the research cited, organoclays were deemed to be more than seventy percent (70%) effective, and a series of systems would be more likely to take that percentage closer to one hundred percent (100%) for any waste being released through those systems.

However, there is a need for more industrial and academic in-field work to be done on the use of organoclays to determine if its long-term exposure or use in the environment would have adverse side effects, so that organoclays can become a much more first line approach to tackling fast food FOG issues instead of conventional methods that have lower efficiency readings.

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