An Analysis on Treatment Technologies for Greywater

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Abstract- In this paper, greywater treatment methods has been studied, which include physiochemical, biological, and advanced oxidation process (AOP) for greywater treatment technologies. These are the technologies that are utilized to eliminate organic pollutants and surfactants that are found in greywater. Comparison of several treatment methods for removing pollutants from greywater will be the primary focus of this research. Comparisons will be made between each technique in terms of its positives and negativesaspects , as well as its potential for use in the development of greywater treatment technologies.

Index Terms- Greywater, water safety plan, treatment technologies, safety of the water supply

I. Introduction

The term "greywater" refers to wastewater that has a low level of pollutants and comes from sources such as bathtubs, showers, hand washing basins, and washing machines. This kind of wastewater does not include wastewater from a toilet flushing system (Murthy et al., 2016). The parameters used to check the quality of the water and wastewater are the biological oxygen demand (BOD), the chemical oxygen demand after five days, and the amount of ultra violet light which is absorbed in organic molecules of the sample at the wavelength of 254 nm. (Zheng et al., 2015).

Before being reused or disposed of, greywater is subjected to varied degrees of treatment, the specifics of which are determined mostly by economic considerations and the required effluent quality. In general, there are three different stages or degrees of treatment.

The initial stage of treating wastewater is called primary treatment, and it is where the vast majority of particles that may float or eventually settle are eliminated. During the initial treatment, about thirty percent of the carbonaceous biochemical oxygen demand that originates from domestic sewage is eradicated.

There are two categories of greywater on the basis of materials present in it:
(1) Light greywater
(2) Heavy grewater (Noutsopoulos et al., 2017).

When compared to heavy greywater, light greywater contains a relatively low amount of pollutants, while heavy greywater contains a significant amount of pollutants. The component of greywater that is being discussed here is made up of organic components, surfactants, nutrients and a trace quantity of metal. however quality of greywater may fluctuate according to the water used in the, activities that use water, and lifestyle choices, the primary contaminants that greywater contains waste from laundry and kitchen. On the other hand value of Total Suspended Solids (TSS) could vary and are generally higher than the normal value. It shows distinct values compare to the physical parameters which are within the standard values that are safe for the environment. The greatest TSS value is seen in kitchen garbage, which includes both beverage and food scraps from the previous day (Noutsopoulos et al., 2017). Although there is less organic material in greywater than there is in black water, according to Temmink et al. (2010), the COD and BOD levels of greywater are still higher than the average level of clean water (Barzegar et al., 2019). The waste from detergents and the little quantity of water that is used during the washing process with cleaning solutions are two factors that contribute to the high level of organic components (Firdayati et al., 2015). The biodegradability is measured by the BOD5/COD ratio (Oteng-Peprah and Nanne, 2018), and the organic material that is often present in greywater has a high biodegradability, which indicates that it can be readily broken down.

II. Brief Assessment

It is estimated that wastewater from public facilities accounts for around 7% of the organic garbage found in the rivers that serve cities in Indonesia. A significant portion of these wastewater discharges are caused by greywater, which travels from residential areas directly into the river via water channels in the absence of an adequate water treatment process.

It has a severe adverse effect on the rivers ecology and its water. (Firdayati et al., 2015). Total production of greywater is directly proportional to the lifestyle, environment, infrastructure, climate and culture (Oteng-Peprah and Nanne, 2018). According to Mohamed et al. (2017), greater part of greywater waste originates from kitchen and toilet. Kitchen waste has greater part of food and drinks left over. On the other hand toilet waste has detergent, soap and urine. Surfactants like ammonia, nitrite, and phosphorus which come from laundry waste are found in significant percentage within toilet waste (Noutsopoulos et al., 2017).

The overall population of Indonesia's urban areas is around 150.9 million people, or approximately 55.8% of the country's total population. The increasing populations of the urban areas are the direct result of growing infrastructure and economic opportunities in the urban areas. Mardiansjah, 2018 Greywater waste originated from urban centers is directly released to rivers and water bodies without any treatment are the main reason of river pollution in Indonesia (Firdayati et al., 2015).

The Advanced Oxidation Process, also known as AOP treatment, is an oxidative chemical technology that primarily produces hydroxyl radicals (OH*) as powerful oxidants in liquid media. This technology is known as the Advanced Oxidation Process. These OH* are very reactive and do not exhibit selective behaviour (Karamah et al., 2019). Photochemical and chemical oxidation processes are the two most common forms of AOP that are used in the treatment of wastewater (Bin and Sobera-Madej, 2014).

Ozone gas and Electrocoagulaton (EC) working together were successful in lowering levels of COD and TOD by as much as 65% and 50%, respectively (Barzegar et al., 2019).

The combination of a Membrane filter and Aeration is responsible for the significant removal of BOD found in greywater. The aeration process increases DO elements, which in turn assists microorganisms in the breakdown of dissolved organic elements (Chao et al., 2019).

III. Treatment Technologies for Greywater

There are a variety of different approaches of treating greywater (also known as GWT), each of which varies in terms of its features, forms, pollutant loadings, and treatment technique. The quantity of greywater, organic substance, usage and acceptability, all play a role in the decision that which technology to choose. There were preparatory procedures, main processes, and secondary processes involved in the treatment. Still there is no conventional standard method for Greywater treatment in the world barring few nations like United States of America (USA) and Australia. However it is based on the origin of Greywater, amount and volume of Greywater, and different usage options. Established methods to treat Greywater are environment friendly method, without using any chemical compound or harmful byproduct. Before the treatment of Greywater some authors advised to store the Greywater for some time. nevertheless, it is important to keep storage periods brief in order to avoid the development of microorganisms (Harju 2010).

Aeration and Membrane bio reactors are few examples of biological technologies. Filtering and disinfection are the main techniques used for physical and chemical groundwater treatment systems. Popular treatment methods are sequence batch reactors, biologically aerated filters and membrane bio reactors. These processes can produce good quality Greywater compared to other traditional processes. These methods are used universally for Greywater treatment. However energy consumption and monetary investment is high in these processes (Allen et al. 2010). hence these methods may be avoided in the middle and low income countries. greater water bills and water conservation methods which was employed in Germany ultimately led to the development of a comlex Greywater treatment system that incorporated dynamic aeration (Shaikh & Zubayed 2013).

There are diverse processes which are used now for segregation of nutrients from Greywater, but these processes are expensive and generates unwanted by product (Alejandro et al. 2010).. Earlier a natural system was used to treat Greywater which was cost effective. It included primary settling with cascaded water stream, aeration, filtration and agitation (Bhausaheb et al. 2010; Saroj & Mukund 2011). Additionally, Microalgae have been suggested as a possible biological treatment that might be used in the process of removing nutrients from wastewater (Jianhua et al. 2012; Wu et al. 2012). The reuse of greywater has the potential to provide a number of advantages if it is implemented correctly. These benefits include the reduction of pollution to bodies of water, domestic freshwater savings, and a contribution to family income savings.

Simple Greywater treatment procedures are being used in the arid regions of United States of America, India, middle east nations and Australia. (Mohamed et al. 2013a). As a result, the treatment of Greywater presents a fundamental difficulty due to the inconsistency of the water itself, which may be seen in factors such as the preferred kind of locally produced good and the culture of the locals (Mohamed et al. 2013b). The system that is used should be constructed in such a way that it is capable of functioning on a modest scale without the utilization of cutting-edge technology. Taking into consideration the fact that the system requires regular maintenance, the biodegradability of the compounds that are introduced into the system will need to be monitored closely in order to prevent blockage. It is possible that, in order to ensure proper operation of the bioreactor over the long term, frequent removal of biomass from the device will be required to meet the regulatory criterion for reuse in irrigation, filtration by natural substances, subsequently a Phyco-Remediation process using Microalgae, is one method that may be employed.

3.1 Domestic Grey Water Treatment methods

Combining Preliminary (physical), Primary (chemical), and Secondary (biological) systems is at the heart of Grey Water Technology. The importance of these technologies may be attributed to the cheap cost of their procedures, the absence of a need for trained staff, the simplicity of their operation, and the high treatment efficiency they provide. In this part, each step of Hybrid treatment system functions in reducing nutrients and improving the quality of water which has been treated.

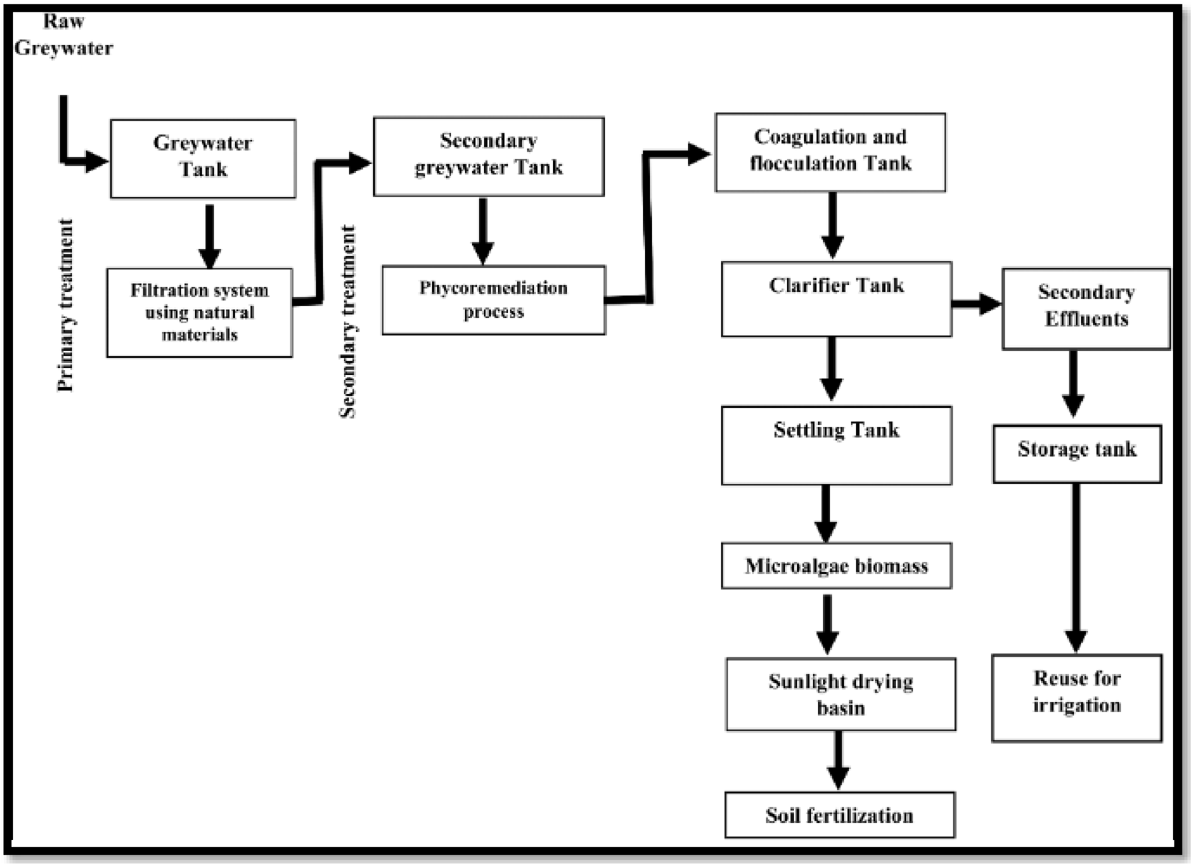

Fig: 1 Hybrid system for treatment of household Greywater

3.2 Physicochemical treatment

Greywater treatments that use physical and chemical processes mostly use filters and disinfectants. Turbidity, Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) may be reduced using the filter technique. Greywater TSS, TDS, and turbidity levels exceeding 80% may be effectively reduced using Sand Filters. This happens as a result of the ions (negative charge of waste colloids) being removed by the tiny sand particles via Ion Exchange and Absorption Processes. Sand also reacts significantly with solids like TSS due to its hydrophobic qualities. Additionally, the Sand Filter will create pore layers that may hold solids. The greywater treatment process will take less time if a sand filter is used alone without any preceding sedimentation stages. Because the majority of the carbon components are dissolved, Sand Filters by themselves are not an efficient way to minimize carbon contaminants in greywater. Additionally, the existence of carbon-oxygen linkages makes carbon contaminants more hydrophilic. In general, adding the Coagulation and Sedimentation Processes before filtering or pairing the sand filter with an active carbon filter may improve the Sand Filter's ability to eliminate carbon contaminants.

Geotextile Filters, such as nonwoven with pore sizes of 0.10 mm to 0.18 mm, are another form of filter that may be used to minimize TSS and COD in greywater. Despite the fact that the majority of suspended particles are less than 0.032 mm, this kind of non-woven Geotextile Filters may lower the concentration of suspended solids by up to 50%, proportionate to the amount of waste loaded. Additionally, non-woven Geotextile decreased levels of COD, BOD5, and TSS by an average of 65%, 68%, and 78%, respectively. As a consequence, the Geotextile Filters and Sand Filter are used in tandem to remove the anionic detergent linear alkylbenzene sulfonate (LAS) greywater component. When its concentration does not exceed the recommended range of 20–50 mg/L, LAS itself is biodegradable. The deposition of suspended particles, agglomeration, and movement of fluids through the Geotextile Filters cause the decrease in organic and suspended solids content. Additionally, the success of the method for removing organic components from greywater is determined by the Geotextile Filters surface's aerobic state.

However, they are less successful in deteriorating carbon pollutants. Physiochemical treatments are highly good at reducing suspended particles in greywater. Additionally, it is ineffectual to remove nutrients from greywater, such as phosphate and ammonia, thus the coagulation process is required for this treatment.

3.3 Biological treatment

Aeration methods and Membrane Bioreactors are the key tools used in the biological treatment process. The bioreactor membrane approach combines biological treatments with physical separation of sediments, while the aeration technique involves adding enough oxygen to the water to encourage bacteria to break down organic contaminants. Sequencing bath reactors (SBR) are one kind of aeration system that may reduce COD levels by up to 90%. This problem arises because the majority of COD in greywater is colloid, which may be more easily broken down by aerobic processes.

Rotating Biological Contactor (RBC)is another aeration technique which is used for the treating Greywater. TSS and BOD removal has been observed by using RBC. TSS levels can be eliminated up to 95% of the time, while BOD concentrations can be removed up to 93% of the time. Due to limited flock formation during the aerobic process and low Dissolved Oxygen (DO) levels in the water, greywater's ability to remove solids is inefficient. The concentration of gas particles, particle size, and solution viscosity all have an impact on how much oxygen is transferred during the aeration process. Therefore, the concentration of DO via the biological treatment plays a significant role in order to boost the effectiveness of eliminating physical solid particles utilizing aeration methods. The membrane bio-reactor (MBR) technology is used for smaller size projects because the aeration process has infrastructural constraints. Greywater COD and TSS levels may reduce by up to 80% and 90%, respectively, due to MBR's strong impact on reducing organic components. Nonetheless, the biodegradation of carbon particles (BOD/COD) had the maximum impact on the elimination of organic components utilizing MBR). As a result, there was little biodegradation and little elimination of waste carbon components.

3.4 Chemical Contaminants

It's essential to comprehend the sources of contaminants in order to identify the different chemical components in Greywater. Greywater has considerable amounts of chemicals from cleaning, cooking, and bathing products. Greywater usually has a pH in the range of 5-9. It significantly depends on the pH and alkalinity of the water supply. Because of the presence of alkaline ingredients used in detergents, Greywater with the majority of its sources coming from the laundry will naturally have a high pH. Surfactants are the core chemical components present in Greywater, which is generated as a result of cleaning or washing operations.) Surfactants are the main chemical components present in greywater, which is produced as a result of cleaning or washing operations.

3.5 Natural filtration unit

The basic treatment for greywater consists mostly of disinfecting the water and removing thecolform bacteria and suspended particles (SS). It was discovered that the system enhanced turbidity and contributed to the decrease of total and faecal coliforms (FC), Total soluble solids (TSS), biological oxygen demand (BOD), phosphorus (P), nitrogen (N), aluminum (Al), Chemical oxygen Demand (COD), and zinc (Zn). Since the coarse filter only has a partial impact on the deduction of the contaminants which is present in the Greywater, it is often tied with soil filtration and given the name hybrid treatment procedure. The main treatment comprised mostly of coarse sand and soil filtration. Via the use of filtering, the removal of particulate matter that has not been accomplished through previous procedures may take place. Although it is possible to remove particles from filtering systems using either physical or biological processes, this evaluation will solely focus on the removal of solids using physical processes since it is the approach that is used in the vast majority of greywater treatment programmes. As filtering medium, one may make use of a wide range of different materials, including sand, gravel, fine mesh, and many more.

To make a filter bed for the filtration unit, diffrent kinds of natural materials have been pooled together. These natural materials comprise sand beds, limestone, wooden sawdust beds, clamshells, coarse size brick beds, charcoal beds, ceramics, beds of coconut shell cover and other fine particles,. The utilization of natural resources as a filter unit, such as in created wetlands, has revealed a great efficiency for the elimination of pollutants, in addition to being cost effective and easy to run. The filtering system was created with bark and activated charcoal; both of them were effective in decreaseing BOD and Total Phosphorus levels by more than 90%. (Lalander *et al.* 2013).

3.6 Man-made Wetland

An artificial wetland called a constructed wetland (CW) is one that has been created using ecological technology to mimic the conditions found in a natural wetland. The technology uses special soil, microorganisms, and flora and fauna to remove important pollutants. They are typically divided into three categories: Floating Treatment Wetland, Surface Flow and Subsurface Flow. The subsurface flow systems, which comes in two main technologies—Vertical Flow Constructed Wetland (RVFCW) and Horizontal Flow Constructed Wetland(HFCW). —have been the most frequently utilized built wetlands. Each one uses a combination of physical, chemical, and biological processes to eliminate pollutants, and the efficiency of the treatment depends on things like the loading rate and the availability of electron acceptors. They have a strong ability to remove BOD, suspended particles, and a few heavy metals, including Pb, Zn, and Fe.

3.7 Advanced Oxidation Process (AOP) treatment

Advanced Oxidation Process (AOP) is an oxidative chemical technologies that primarily generates powerful oxidants in liquid media called hydroxyl radicals (OH*). These OH* exhibit great reactivity and lack of selectivity. The two main types of AOP employed in wastewater treatment are chemical and photochemical.

UV light is a typical photochemical technique in the water treatment process. When greywater is treated with UV light, the radiation causes excitation and ionization reactions, which might result in the formation of OH*, While the UV light is selective in reducing different organic waste components, it is ineffective in eliminating other waste contaminants; as a result, it must be used in conjunction with other substances to maximize its efficacy. Chemical type AOP treatment employs hydrogen peroxide (H_2O_2) or ozone as a component to create OH*; however, because to the limited elimination of organic waste, ozone and H_2O_2 alone are ineffective. Additionally, compared to mixing these two chemicals, such as UV/ozone or UV/H_2O_2, the treatment period is also rather lengthy. The biodegradable index increases as a result of the removal of organic components utilizing AOP through UV/H2O2 technology, enabling wastewater to undergo further chemical and biological treatment. Ozone and EC together were able to lower COD and TOD levels by up to 65% and 50%, respectively. Ozone may be activated by EC using iron electrodes to create OH*. The amount of ozone present is essential for the production of OH*, which is necessary for the breakdown of organic molecules. The levels of COD and TOC decrease with increasing ozone doses, although it should be noted that a dosage of 47.4 mg/L is enough to reduce COD by up to 70%. Ozone has a tendency to inhibit rather than promote the synthesis of hydroxyl radicals when the decrease is more than 70%.

3.8 Membrane Bioreactor Technology (MBR)

The term "greywater," means the total amount of wastewater generated in residences or office buildings from streams that does not include faeces. The term "greywater" refers to the wastewater that is typically produced by showers, bathtubs, washbasins, and washing machines. The fact that the treatment of greywater is simpler than the treatment of municipal wastewater has led to a significant increase in awareness in its reuse and recycling. The focus is to increase the non-potable uses such as flushing of toilets, irrigation these are examples of typical applications for the recycling and reusing of greywater.

The effective reuse of wastewater is an essential component of the environmentally responsible management of water resources. In arid and touristy regions, where the highest water demand is often experienced during the dry season, greywater has the potential to be a significant and useful alternative water supply. Recycling greywater might have a number of positive effects on the environment, including the following:

- Water treatment plants and Septic tanks have a less harmful influence on the neighboring environment.
- Less freshwater would be taken from rivers and aquifers.
- Water treatment facilities consume less energy and produce less chemical pollution.
- Recharging the groundwater supply and reclaiming the nutrients.

On the other hand, greywater may be tainted with a variety of different compounds, some of which are soluble while others are not, and so it has to be handled appropriately. In addition to residues of dirt, food, grease, hair, and some home cleaning products, greywater may include other contaminants as well. Primary greywater treatment typically consists of using aerobic and biological treatments to remove dissolved and suspended biological matter, followed by ultra-filtration to prevent particles, germs, and viruses from passing through. In the end, greywater may be sanitised using UV light and/or chlorination in order to guarantee that there will be some residual disinfection at the point of utilization.

In highly populated touristic destinations, where space is definite and has a great value, dependable and compact solutions are required. It appeals the technology of membrane bioreactors a very attractive choice as a substitute to consider. The Activated Sludge Process and Membrane Filtration are both the components of the MBR process, which stands for membrane bioreactor (ultra filtration or microfiltration). When compared to other types of treatment systems, MBR offers a number of distinct benefits, including the following:

- Greater effluent quality and least sludge production
- small and very stable design
- exceptionally little sludge output

Membrane bioreactors merge biological treatment with physical membrane barriers in order to eliminate the need for clarifiers and media filters while also reducing the size of the reactor. Due to these qualities, MBR is an ideal technology for use in greywater treatment systems as well as greywater recycling.. Pumps, bioreactor tank, and Plumbing, are the usual components that make up Greywater systems, where the biological treatment takes place and where the water is filtered via a membrane.

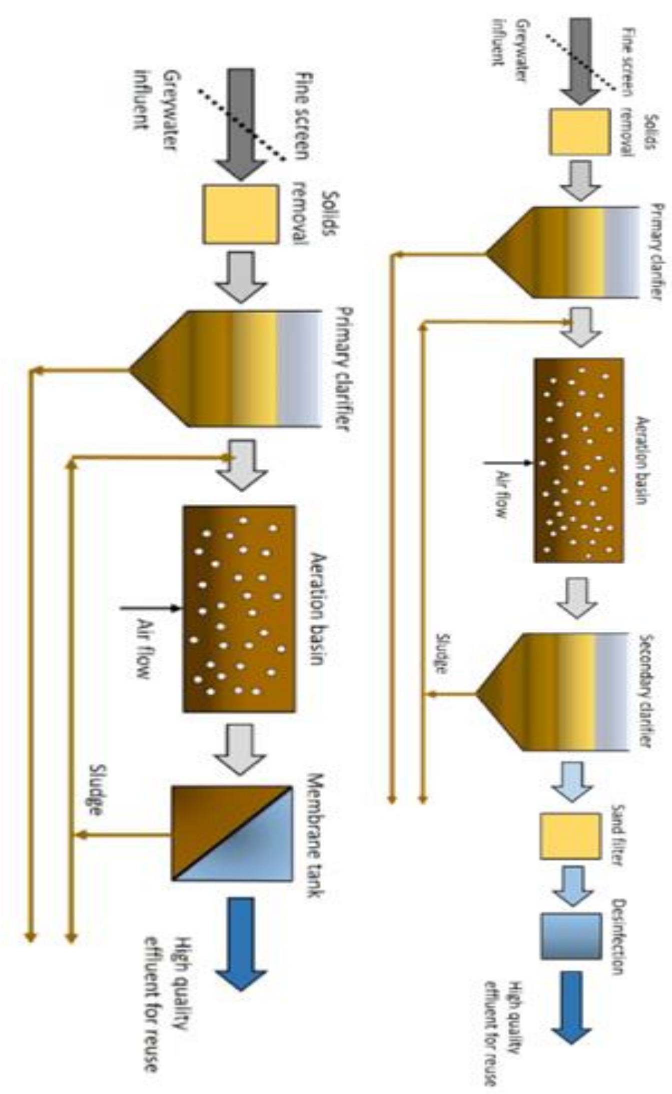

Fig 2: Greywater treatment

Lenntech offers environmentally friendly and comprehensive solutions for recycling greywater, taking into consideration a diverse array of technologies and approaches. Reclaiming greywater is an appropriate approach for lowering our water footprint and our water expenses in light of the rising demand for water throughout the globe as well as the shortage of fresh water.

IV. Conclusion

This is a comprehensive study on the existing technologies for treating greywater, including Greywater treatment which included biological, advanced oxidation processes (AOP), and physiochemical processes, and that is used to segregate greywater pollutants such as surfactant, nutrient, and organic pollutants. Due to the simplicity of its installation and use on a modest scale, the AOP technology has the potential to be commercialized as a greywater treatment solution for the general populace. Additionally, since AOP is able to degrade all of the constituents that contribute to greywater pollution, it is an excellent solution for lowering greywater pollution levels.

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