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Advances in Microfiltration and Ultrafiltration Technology for Greywater Treatment: A Review

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ABSTRACT

Advances in microfiltration and ultrafiltration technology for the treatment of greywater are important today because everything surrounding the use and preservation of water is an issue that increases in importance over the decades, and our planet will be seriously affected by the consequences of climate change, making water availability uncertain. Hence, wastewater recycling and its cyclical use have become a major topic in the scientific and engineering communities. The objective of this research is focused on compiling and updating all the advances in wastewater treatment, with emphasis on Greywater, in which components have a lower pollutant load than the rest of wastewater. In addition, microfiltration and ultrafiltration technologies were the technology selected to investigate in this investigation because they have the local potential for a second use of the wastewater before the discharge of contaminated water to the sanitation network. This research was carried out using words related to the exposed topic, such as "microfiltration", "ultrafiltration", "cleaning wastewater" and "greywater" in the search for documents in scientific search engines, selecting those that covered the topic and could be used to create this document. The results that were developed in this investigation, indicate that there is no generalized consensus on how to treat this greywater, nor how to qualify it. Additionally, it is important to note that despite the fact that urban greywater treatments have given good results, with the widespread use of bioreactors for this task, and the existence of various treatment alternatives for liquid waste that have shown good price-value ratio, studies related to greywater treatments using porosities are still in the incipient stages.

INTRODUCTION

Today our water resources are more threatened around the world than ever before, due to rapid population growth, as well as industrial use of water, thus large bodies of water are required to create a good or perform a service.

On the other hand, as a consequence of man's various activities, wastewater is generated, which varies from one location to the other, but urban areas are characterized as areas where wastewater is being the most generated, and the fluid that does not come from the restroom is referred to as Greywater. Given the abundance of such wastewater, recycling is one of the main options when seeking new water sources in water-scarce regions, and wastewater treatment provide an effluent of sufficient quality that can be beneficially used instead of discharged.

There is greater interest in the reuse of grey water, given that its pollutant load is lower than that of other wastewater, and it can be attributed to some second use before its subsequent discharge into the waste network. Pore filters are good for use in cleaning these fluids since their equipment is not too complex, and the technology would help to recirculate a significant amount of water and reduce demand for water within the same community (Li et al. 2009, Yokomizu 1994).

The focus of this research synthesis is on the updating of data related to this topic, as well as its future forecast. Despite the possible limitations to be solved in the process of cleaning Greywater by UF/MF, it continues to be a tentative and sustainable operation that allows people to reduce water consumption and decrease the impact of the human footprint on the deterioration of the ecosystem.

WORKING METHODOLOGY

The work methodology in this review is the search, compilation, study, segregation, synthesis, and formulation of conclusions from scientific publications related to the issue of wastewater recycling using the technology of filtration

Initially, an exhaustive investigation was carried out in scientific search engines as "Scopus", "Web of science", "Sciencedirect", "Researchgate", "Scielo" and "Google Scholar" with the keywords "microfiltration", "ultrafiltration", "water treatment" and "greywater", having a preference to publications of the last decade although ad-

mitting more old material. As a result of this procedure, all publications whose abstract coincided with the focus of this synthesis were analyzed, obtaining a list of publications that were compiled for the study of the advance of Greywater recycling in microfiltration and ultrafiltration technologies in the last decade.

After a detailed review of all the articles set, we proceeded to classify them according to the objective of this study, and from those we proceeded to extract the information linked to the topic of this study. Finally, some conclusions were established from the material found in the scientific library.

GREY WATER

Greywater is all wastewater generated in urban buildings without the presence of fecal contamination. Greywater constitutes 50-80% of total domestic wastewater, and the flow in developed countries is estimated between 90 and 120 L, produced by one person per day (Li et al. 2009). The chemical composition of Greywater is variable, however, its physicochemical characteristics vary in a certain range that is presented in Table 1. Likewise, there are also certain common contaminants that can occur in Greywater, such as Parabens, preservatives (Metilparabens (MP), ethylparaben (P), propylparaben (PP), butylparaben (BP), isobutyl parabens (isoBP)), Fragrances: (Tonalide, galaxolide HCA), surfactants (Triclosan, BaCl2, nonylphenol), UV Filters, plasticizers, anionic Surfactants, among others) (De Gisi et al. 2015)

Numerous studies have been conducted on greywater treatment with different technologies that vary in both complexity and performance. However, specific guidelines for Greywater reuse are not available or sufficient and studies on the assessment of appropriate technologies for Greywater

reuse/recycling are scarce. Nevertheless, despite the few existing data in the bibliography, there are some environmental standards in some countries that regulate the quality of recycled water from Greywater should have. In the rest of the world, countries where there is no standard definition of Greywater, this one is treated as wastewater without any distinction from other liquid contaminants, and it is treated in common areas of cleaning and disinfection

GREYWATER TREATMENT TECHNOLOGIES

There are different Greywater treatment technologies, categorizing in physical, chemical, and biological treatments. Most of these technologies are preceded by a solid-liquid separation pretreatment and followed by disinfection as a post-treatment (Li et al. 2009).

Physical treatments include coarse sand, soil, and filtration by membranes, followed mainly by a disinfection step since coarse filtration has only a limited effect on the removal of contaminants present in Greywater (March et al. 2004).

Regarding the chemical cleaning processes of Greywater, there are not many technologies about them, which include coagulation, photocatalytic oxidation, ion exchange, and granular activated carbon (Li et al. 2009).

In terms of biological treatments, there are several processes, such as rotating biological contactor, sequencing batch reactor, anaerobic sludge blanket, and constructed wetland and membrane bioreactor (MBR), that have been applied for Greywater treatment, often preceded by a physical pretreatment step, such as sedimentation, use of septic tanks or detection. In addition, most biological processes are followed by a filtration step (e.g. sand filtration) and/or a disinfection step to meet non-potable reuse standards (Li et al. 2009, Jefferson et al. 2004)

Table 1: Characteristics of the different categories of Greywater.

Characteristics	Bathroom	Laundry	Kitchen	Mixed
pH (-)	6,4-8,1	7,1-10	5,9-7,4	6,3-8,1
SST (mg.L^{-1})	7-505	68-465	134-1.300	25-183
Turbidity (NTU)	44-375	50-44	298,0	29-375
COD (mg.L^{-1})	100-633	231-2.950	26-2.050	100-700
DBO (mg.L^{-1})	50-300	48-472	536-1.460	47-466
TN (mg.L^{-1})	3,6-19,4	1,1-40,3	11,4-74	1,7-34,3
TP (mg.L^{-1})	0,11->48,8	ND- >171	2,9- >74	0,11-22,8
Total Coliforms (CFU.100 mL^{-1})	10-2,4x10^7	200,5-7x10^5	>2,4x10^8	56-8,03x10^7
Faecal Coliforms (CFU.100 mL^{-1})	0-3,4x10^5	50-1,4x10^3	-	0,1-1,5x10^8

After Li et al. (2009)

GREYWATER TREATMENT THROUGH ULTRAFILTRATION AND MICROFILTRATION

Filtration is one of the key processes in water treatment, and with the advance of technology, this mechanism has improved over the years. Microfiltration (MF) is defined as a surface of variable shape, with pore sizes ranging from 10 nanometers to 1,000 Armstrong. Ultrafiltration (UF) is also defined as a porous surface, with the difference that pore sizes can vary from 1000 to 50 Armstrong (Koyuncu et al. 2015).

Worldwide, global investment in MF was \$1.6 billion in 2013 and projected to be \$2.6 billion by 2018. Global investment in UF was \$882 million in 2013 and was projected at \$1.2 billion in 2015 (Koyuncu et al. 2015).

These surfaces are made of membranes, whose characteristics vary according to the material they are made of, as well as the physical characteristics they have depending on the purpose they are intended to achieve. The most commonly used membranes are polymeric, due to their low cost, are easy to shape, and have some chemical and thermal resistance. The most used polymers are cellulose acetate, PVDF, PA, PP, and PES (Koyuncu et al. 2015).

However, ceramic membranes are better than polymers because they have better pore distribution, higher porosity, better separation characteristics, greater chemical, and mechanical stability, and are optimal for Greywater treatment because unlike polymers they resist bacterial activity better, which gives them a longer life. Some characteristics of UF and MF membranes are presented in Table 2.

It is important to adjust a hypothetical model that collects representative average data from different samples in other studies to evaluate the performance of these membranes in the treatment of Greywater, with their varying properties due to the difference that happens from their origin (Eriksson et al. 2002). A model of water was hypothetically created by Friedler (2004). From this model, different efficiencies can be evaluated, and it is possible to see the potential of the cleaning process for these waters. Table 3 shows the physical characteristics of this hypothetical fluid.

PHYSICAL TREATMENT OF GREYWATER

Physical processes alone are not sufficient to ensure adequate reduction of organic and inorganic contaminants. However, the process to be used depends on the purpose for which it is intended (Li et al. 2009)

For example, Kyu-Hong et al. (1998) demonstrated that the application of a tubular membrane of both UF and MF meets the quality standards for secondary uses such as bathing water in hotels according to the Israeli legislation (Israel Ministry of the Environment, 2001).

Regarding the physical cleaning of grey water, Bhattacharya et al. (2013) discussed the potential of ultrafiltration and microfiltration ceramic membranes in tubular membranes. The experiment carried out in this study is the treatment of Greywater driven by a difference in pressure of nitrogen gas in the liquid. The fluid is driven into treatment in three different spatial arrangements, one where the water is treated by microfiltration, another by ultrafiltration, and in the third configuration, the Greywater passes through a microfiltration filter and then by an ultrafiltration filter. In addition, they compared the effects of treated versus untreated Greywater in the Chrysalidocarpus Lutescens plant, because it represents

Table 2: Characteristics of MF and UF membranes.

	Micro filtration (MF)	Ultra filtration (UF)
Mode of operation	Crossflow and dead point of operation	Crossflow and dead point of operation
Accuracy of operation	0,1-3 bar (transmembrane)	0,5-10 bar (transmembrane)
Mechanism of separation	Separation based on the size of the particle	Separation based on the size of the particle
Molecular size of the separation	Solids: $>0,1\mu m$ Separation of particles	Colloids: 20.000 - 200.000 Da Solids: $>0,5\ \mu m$ Macromolecule separation
Type of membrane	Predominantly symmetrical polymer ceramic membranes	Composed of asymmetric polymer or ceramic membrane
Type of module	Spiral winding, hollow fiber, tube modules, plate or cushion modules	Spiral winding, hollow fiber, tube modules, plate or cushion modules
Negligible osmotic pressure	Negligible osmotic pressure	Negligible osmotic pressure
Thickness of the separation layer	symmetrical = 10-150 µm asymmetrical = 1 µm	0,1-1,0 µm

After Koyuncu et al. (2015)

Table 3: Synthetic greywater (SGW, nine samples).

Parameters	Units	m	σ	min	max
pH		6.76	0.30	6.29	7.29
Conductivity	µS/cm	188	18	159	212
Turbidity	NTU	24	16	4	42
Suspended Solids	mg.L^{-1}	72	14	41	87
COD	mg O$_2$.L^{-1}	454	33	391	505
DBO$_5$	mg O$_2$.L^{-1}	65	6	58	75
DOC	mg.L^{-1}	132	14	106	149
A-surfactants	mg.MBAS.L^{-1}	49.1	11.5	33.5	69.8
Total coliforms	CFU.100 mL^{-1}	3.8×10^3	2.5×10^5	9.6×10^4	8.4×10^5
Fecal coliforms	CFU.100 mL^{-1}	9.6×10^3	1.4×10^4	1.6×10^2	4.1×10^4
Enterococcus	CFU.100 mL^{-1}	2.7×10^3	2.6×10^3	5.3×10^1	8.2×10^3

m: average; σ: standard deviation; min: minimum; max: maximum; After Friedler (2004)

well the soil quality during its development (Bhattacharya et al. 2013).

As a result of this experiment, MF retained turbid materials and suspended solids (almost 99% removal), with 75% COD removal. However, there were several harmful particles that passed the filter. UF had good retention of turbidity and suspended solids (over 99%), oils, and microorganisms, in addition to a COD reduction of 86%. As for the mixed process, where MF and then UF were used, a large amount of contaminants were eliminated, in addition to having a 92% decrease in COD (Bhattacharya et al. 2013).

In the experiment of the Chrysalidocarpus Lutescens plant, the quality of the treated water and its interaction with the soil was tested by irrigating this plant with untreated water and water treated with the three techniques outlined. Normal growth was observed in all cases. Bhattacharya concluded that the water treated by physical filters could have a second use that does not involve human consumption (Bhattacharya et al. 2013)

On the other hand, according to Blumental (2000), the physical treatment of Greywater without the addition of any biological additives does not have enough study evidence to conclude its safety with the environment. However, the treated waters meet the physical-chemical criteria of standards for agricultural use in the United Kingdom, because filter-treated Greywater is considered to meet standards for a second use

Majouli et al. (2012) described the preparation of a tubular membrane made of Moroccan ceramics, driven by a pressure difference between the fluid in the system. The contaminants are retained in the tube while the treated water exits through the pores.

The results obtained by measuring the effectiveness of the process in the study, which does not focus on Greywater but explicitly states that the results can be extrapolated for this type of pollutant, are promising; they observed the removal of 97 percent of turbidity, making the water usable for secondary purposes such as agriculture. The most outstanding aspect of this study was the use of Moroccan ceramics, which is easily available in Morocco, and after applying a physical treatment, the shape and porosity of the filter are applied, being ready for use at a laboratory level (Majouli et al. 2012).

Chihi et al. (2019) introduced another microfiltration membrane, replacing the cylindrical shape (which is the most common) with a flat ceramic filter, which has not been evaluated for the use of Greywater but has been tested for the use of industrial water. The operation of this flat plate filtration is from stimulating the flow of water through pressure differences, retaining pollutant particles on the filter.

The main advantage of this flat plate membrane is that its main raw material is tunes clays, which are cheap and abundant, and it has to be put in treatment to give the shape, quantity, and quality of pores desired. The plates have good physical, chemical, and biological stability, good pore distribution, and may be more economical to operate (Chihi et al. 2019).

Saja et al. (2017) described the preparation of a flat plate membrane made of Moroccan ceramics, for the treatment of industrial waters on a laboratory scale, also scalable to Greywater.

The membrane model is a microfiltration plate with an average pore size of 1.7 mm and 52% physical space porosity on its surface. It is installed in a system that pumps water

to this filter. The treatment removes 97 percent of turbidity, allowing the water to be used for secondary purposes such as agriculture while also meeting water quality criteria. It also has the potential to improve the quality, quantity, and affordability of Moroccan ceramics (Saja et al. 2017).

PHYSICAL-BIOLOGICAL TREATMENTS OF GREYWATER

Greywater treatment through UF/MF can be optimized by adding biological material which turns the technology into a physical-biological treatment. Over the surface of the filters, which contain the particles that pollute the liquid, bacterial activity is introduced, which destroys the contaminants in the water, boosting the effectiveness of the membranes and, as a result, the cleanliness of the treated liquid. (Ramona et al. 2004).

The process over the membrane is a bio-action carried out on the membranes with porosities of sizes corresponding to microfiltration and ultrafiltration. This is achieved by adding biological material on the surface to remove complex chemical contaminants and then filtering them from the membrane. This type of mechanism is called "membrane bioreactors" (MBR) and has been widely tested, with acceptable results for secondary use water without further treatment (Jefferson et al. 2000, Jefferson et al. 2004, Ramona et al. 2004). According to the regulations for reusing Greywater, it must comply with hygienic aesthetic aspects, environmental tolerance, and economic stability (Kyu-Hong et al. 1998, Nolde 2005, Jong et al. 2010).

The so-called "membrane bioreactors" deliver a cleaner water quality than the physical membranes, however, they are more expensive, and the effluent that these processes deliver is always non-potable secondary use water, although they do not need to be further treated and can be discharged to the environment (Li et al. 2009, Jefferson et al. 2004).

However, Jong et al. (2010) found with a study of Greywater after a traditional MF membrane bio-reactor treatment, that although the physicochemical parameters satisfy those required by Jung's Korean standard (Jung's Korean Standard 2004), it is definitely not safe to use this water for secondary use without subsequent treatment. There is still a significant presence of bacterial load harmful to health, and the ecosystem after this process.

Samples of *Escherichia coli Staphylococcus aureus,* and *Salmonella tyohimmurion* were measured in the Greywater effluent once it was treated under the conditions of those studies. The measurement showed that it was lower than that of the entrance, but with sufficient presence to be able to generate environmental or health problems, which prevents a safe secondary use.

Continuing with the main topic, Drews (2010) exposed the advantages and disadvantages of this type of reactor with ultrafiltration pore size. The positive characteristics are the benefits in the form of reduction of the CO_2 footprint, the reduction of excess sludge, and the high liquid flow, while as disadvantages are the decrease in production and performance over time, frequent cleaning, damage, and maintenance, difficult aeration and loss of permeability, among others. Another major impediment to bio-reactors is the costs associated with implementation and operation, which are proven by the existence of cost estimates for the submerged membrane bio-reactor (traditional bio-reactor, more studied in the literature), for the treatment of Greywater (Humeau et al. 2011).

This is demonstrated by a market study, such as the one conducted by Hourlier et al. (2010), where it presents market data for an ultrafiltration submerged membrane reactor, for a community of 50 inhabitants and a community of 500 people, of 60-second operation, with 5 seconds of pause, 20 seconds of counter-current water and 5 seconds of rest, in

Table 4: Fixed costs related to equipment (MBR).

Parameter	50 inhabitants ($3m^3.day^{-1}$)	500 inhabitants ($30m^3.day^{-1}$)
Total investment cost	38.100 €	183.800 €
Cost of the process	36.000 €	180.000 €
Membrane área	59 m^2	589 m^2
Area per module	60 m^2	100 m^2
Module unit	1	6
Raw Greywater storage tank	750 €	1.200 €
Permeate storage tank	750 €	1.200 €
Heat Exchanger/ Air Compressor	600 €	1.400 €

After Hourlier et al. (2010)

a cyclical process, with a membrane pressure of 0.5 bar to treat Greywater.

All of the above is carried out according to the model of Hourlier et al. (2010). This study takes into account direct costs (fixed costs, equipment, depreciation, and maintenance), variable costs (electricity consumption, chemicals), indirect costs (administrative charges, contingency costs, insurance), and possible benefits. The results are presented in the following Tables 4 to 6.

Hence, given the data observed in the tables, it is concluded that the average operating costs are 7.4 euros.m^{-3}, with a plant capacity of 3 m^3.day^{-1} for 50 people, and 30 m^3.day^{-1} for 500 people, with average direct costs of 4.4 euros.m^{-3}. Therefore, although the submerged membrane bioreactor is the most studied and widely used bio-reactor, it has the disadvantage of being very expensive and difficult to operate, which makes it only profitable in small communities like a building (Li et al. 2009, Jefferson et al. 2004, Ramona et al. 2004).

In addition to the previously mentioned limitations, including their cost, bio-reactors present another main dis-advantage, corresponding to their fouling. To solve this, various techniques are usually used, among which are physical techniques such as: backwashing, optimization of process parameters, different membrane configurations, application of ultrasonic technology (Jie et al. 2012, Hwang et al. 2009, Schoeberl et al. 2005, Xu et al. 2011).

And additionally, they also use chemical techniques such as: adding chemical coagulants (ferric sulfate, alumina, aluminum salts, among others) or add adsorbent materials like carbon or zeolites (Lee et al. 2001, Hu & Stuckey 2007, Tian et al. 2010, Wu & Huang 2008)

As a result of all these limitations of traditional membrane bioreactors, several alternatives have emerged with some improvement or update in their process. Some examples are:

a) Bani-Melhem et al. (2014) discussed a type of tradi-tional membrane reactor, submerged, varying from the common bioreactor in its configuration uses of tubular hollow fiber with porosities of submerged ultrafiltra-tion, which treats water for 42 days and at 13 kpa. The water is driven by a vacuum pump that forces it to pass filtered through ultrafiltration bio-membranes. This

Table 5: Variable costs related to equipment (MBR).

	50 inhabitants (3m^3.day^{-1})	500 inhabitants (30m^3.day^{-1})
Cost of working	2.650 €.year^{-1}	8.875 €.year^{-1}
Total time of working	106 h.year^{-1}	355 h.year^{-1}
Inspection, maintenance and revision	20 h.year^{-1}	48 h.year^{-1}
Consumable Supplies	72 h.year^{-1}	288 h.year^{-1}
Frequency	1,5/month	6/month
Duration of intervention	4 h	4 h
Sowing of the Bio-reactor	8 h.year^{-1}	8 h.year^{-1}
Frequency	1/year	1/year
Duration of intervention	8 h	8 h
Membrane replacement	6 h.year^{-1}	11 h.year^{-1}
Duration of the replaced module	4 h.year^{-1} r	8 h.year^{-1}
Duration of intervention	2 h.year^{-1}	3 h.year^{-1}

After Hourlier et al. (2010)

Table 6: Indirect costs related to equipment (MBR)

	50 inhabitants (3m^3.day^{-1})	500 inhabitants (30m^3.day^{-1})
Membrane replacement cost	1.500 €	13.500 €
Membrane unit cost	3.000 €	4.500 €
Number of units of the module	1	6
Membrane lifetime	2 years	2 years

After Hourlier et al. (2010)

MBR technology is a good option to treat Greywater with good removal of organic substances, surfactants, and microbes without further steps. After 40 days, at 13 kpa and 25°C, a DQO removal of 89%, 95.2% color, complete removal of suspended particles, ammonia removal of 89.4%, phosphorus removal of 56%, and COD removal of 89.3% were noticed

b) Ding et al. (2017) discussed gravity membrane reactors with microfiltration flat plate membrane size as an alternative to MBRs. They are thought to be equally as capable as other forms of bioreactors, and they are less expensive because they do not require energy to propel the effluent. In the experiment, the study compares two gravitational membrane reactors, one which is aerated and the other is not aerated.

The conclusion reached in this study is that MBR has higher efficiency than the reactors proposed in this research. The experiments carried out in the reactors, provide good effluent effectiveness for both reactors, being aerated with better results. However, these do not reach the quality of MBRs, although it is more profitable to build them, and they need more physical space (4-5 times the non-aerated, meanwhile 2 times the other one) to treat the same amount of water with the same quality as bio-classic membrane reactors.

c) Jaborni & Podmirseg (2014) discussed a semi-tubular fixed with porous in the surface of the membrane bio-reactor with submerged ultrafiltration porosity size, except for having a sand pre-filter and using a smaller volume in each unit. As a result of the use of the pre-filter, the membranes do not get dirty, the flows are stabilized beforehand, the membranes do not use catalysts, the flow is clean of physical impurities, and fixed membranes are used because in that configuration the recycling of the microorganisms on the membrane increases.

They concluded that the effectiveness of this type of reactor complies with the international standards of the International Standard/American National Standard (2011) on treatment systems for residential and commercial in-situ water reuse. However, the amount of flow is lower and the energy expenditure is higher compared to the conventional submerged membrane bio-reactor.

d) Huelgas & Funamizu (2010) described a submerged ultrafiltration flat plate bio-reactor with a constant TMP since the water flow is from a difference in level between the inlet and the reactor. Finally, the effluent is clean, with a COD reduction of 96% and suspended particles eliminated greater than 99% after 86 days, indicating that the efficiency and output flow are lower than a typical membrane bio-reactor.

e) Bani-Melhem & Smith (2012) exposed two reactors that treat Greywater in the same conditions at the same time; a traditional membrane bioreactor, and a submerged UF membrane bio-reactor, with the exception of an electrocoagulation pre-treatment for the elimination of microorganisms. As a result, the permeate flow is faster than one without pre-treatment, the turbidity decreased by 97%, compared to 95% for a traditional one, and in both the color disappeared almost 100%, (the color by 94% in the modified one and by 91% in the traditional one). Suspended solids were also almost completely eliminated in both processes, and coliforms dropped by approximately 40% in both cases. The COD dropped by 89% in the modified process and by 86% in the unmodified one.

In conclusion, the improvements to the reactor provide a better quality effluent, but not in a significantly considerable quantity, therefore it does not have an economic projection because its implementation entails higher economic costs without being profitable.

f) Finally, Jabornig & Favero (2013) discussed the treatment of Greywater with non-fixed bed bio-layer, with a tubular membrane of ultrafiltration porosity, called "BF-MBR; biofilm membrane bioreactor. The study exposed in this study is divided into two compartments; the first one with non-fixed bio-layers and the other one with membrane modules that act as filtration, and the sludge is recirculated, producing a higher flow than the conventional one, and more economical to maintain.

The effluents from this equipment meet the NSF/ansi350 (NFS 2017) criteria, with a DOC reduction of 64%, a BOD turbidity of 83%, and almost 100% suspended solids.

CONCLUSIONS

Research and implementation of Greywater reuse through treatments that include microfiltration and ultrafiltration are still in an early stage, with a lack of significant studies seeking improvements to the traditional model. There is also no shortage of industrial-scale implementations and scaling up to treat effluents collected from a community.

According to what has been studied, analyzed, and sought in this research, there is not a large amount of literature that addresses the deficiencies of this technology for the treatment of Greywater, the possible improvements, the associated costs, among others. The amount of information available concerning assembly in the implementation of this technology at a city or industrial level is limited, as investments in this sector of the industry are sparse. Despite the above, there are compelling historical studies that guarantee that water

treatment by submerged membrane bio-reactors, (which are the most commonly used types of filters in this topic), is successful for secondary use water discharge without any post-treatment.

There is also a lack of studies on the treatment of Greywater by physical treatments, the vast majority of the literature focuses on the treatment of industrial water. In spite of that, it can be determined that water treated in this way can be reused in a closed circuit from a separate collection for uses that do not demand such high water quality, such as the use of this water for toilets, recirculating water within a community before being discharged to the sanitation network

It should also be noted that the pattern for defining Greywater and its characteristics is variable, depending on local regulations defined in some countries, while in the rest of the world, discharge water is considered discharge water without any special name, and there is no global regulation for its treatment, so its regularization is dependent on the geographical. It is to be hoped that in the future those places that do not have special legislation for this type of fluid discharge, will carry out an environmental agenda that can take advantage of the benefits of treating Greywater differentiated from the rest of the fluids that are loaded into the network sanitation.

It is expected that, in the future, the amount of research into Greywater treatment by MF/UF will increase, and that, as a result, scientific progress will improve the technical and economic flaws in this industry, motivating various governments and institutions to implement this technology in situ to alleviate global water demand.

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