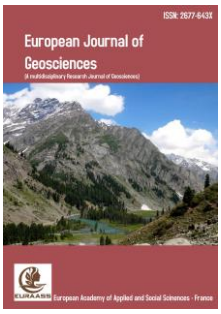
EUROPEAN JOURNAL OF GEOSCIENCES - VOL. 02 ISSUE 01 PP. 30-37 (2020)

European Academy of Applied and Social Sciences – www.euraass.com

European Journal of Geosciences

https://www.euraass.com/ejgs/ejgs.html



Research Article

Comparison of Biological and Nanofiltration methods to reduce the BOD5 of industrial wastewater for the reuse and access to sustainable water resources in urban areas, A case study of Najaf Abad in Iran

Mohammad Mahdi Kohansal[a], Sara Saadati[b*], Saeid Eslamian[c]

[a] *Irrigation and Drainage Engineering, Isfahan University of Technology, Isfahan, Iran. Email: mm.kohansal@gmail.com*

[b] *Natural Resources Engineering, Isfahan University of Technology, Isfahan, Iran. Email: saadati.sara@gmail.com*

[c] *Department of Water Engineering, Isfahan University of Technology, Isfahan, Iran.*

Received: 06 July 2019 / Revised: 07 December 2019 / Accepted: 04 January 2020

Abstract

The rapid increase of human population accompanied by industrial growth and rising standards of living has resulted in heavy demand for water across all sectors. So, treated wastewater could be an unlimited and stable alternative for water supply to use in irrigation and industry and plays an important role to achieve sustainable urban development. Nowadays, finding an appropriate wastewater treatment & reuse method is one of the important issues which many research has been conducted in this field. The aim of this study was to compare the treated wastewater (industrial) by biological method compared to the nanofiltration method and determine more suitable method for industrial wastewater treatment. Thus, BOD5 of industrial wastewater was used for this purpose and the appropriate method was chosen by calculating the percentage and percentage of this parameter as well as analyzing the significance of the difference between the results of the two methods used by SPSS software. The nanofilter used in the study was made from carbon-neon and the pressure of its desired performance has been 10 times and the diameter of the stomata is 50-80 nm. Also, all experiments were performed weekly for a period of 11 weeks in Najaf Abad wastewater treatment plant. The results showed that the mean BOD5 = 6.87 mg / L measured by nanofiltration method while the mean BOD5 is 9.91 mg / L by biological method. According to the results, the nanofiltration method is more effective than the biological method. Nanofiltration method is suggested to prove the superiority and other water quality parameters are also tested.

Keywords: Nanofiltration, Biological, Treatment, Industrial Wastewater, Sustainable Development.

1. Introduction

Global population is increasing day by day and available water resources are dwindling. The world will face serious water shortages in the near future as this trend continues. The limitation of water resources and the uncoordinated distribution of precipitation show the need for the use of wastewater, especially in the agricultural sector. The recycled wastewater could be considered a new source in the water resources management system which due to the lack of water resources in recent years, the use of these resources as vulnerable and alternative water resources is vital and more important over time. It should be noted that water resources management is to ensure the

* Corresponding author: Email address: saadati.sara@gmail.com (Sara Saadati)
Available online: 24 February 2020
DOI: Yet to add
Journal reference: *Eur. J. Geosc.* 2020, 02(01), 30 – 37.
ISSN-E: 2677-643X.

Cite as: *Kohansal M. M, Saadati S, and Eslamian S (2020) Comparison of Biological and Nanofiltration methods to reduce the BOD5 of industrial wastewater for the reuse and access to sustainable water resources in urban areas, A case study of Najaf Abad in Iran. Eur. J. Geosc. 02(01), 30 – 37.*

sustainable use of water supply.

Water treatment has been proposed and acknowledged as a necessity in human life. Diseases caused by water pollution endanger human health every day and results in the death of thousands of people around the world. In the meantime, the increased ability to reuse water creates the possibility of prolonged access to a good source for various applications (Mohammadi, 2014). Due to population growth and industrial development, previously unaffected communities are now faced with drinking water contamination. Infectious diseases are transmitted through contaminated due to lack of accurate and complete water treatment. These interpretations imply the high importance of water treatment (Eslamian, 2011).

Hence, water treatment has been proposed as a necessity in human life. Household drinking water treatment devices are no longer a luxury; they play a great role in improving the quality of drinking water and the Family Health (Kohansal, 2014). Scientific research has proven that health and human life is highly dependent on water quality. Today, nanotechnology is a Priority and strategic Technology for all countries and is very important due to its' extensive functionality and direct impact on most industries and science. That is why this technology is widespread in recent years with the rapid growth and extraordinary expansion in many areas, So that, this technology is mentioned as a key and effective technology on science and technology in the world of and Some programs at national level are implemented to support Industrial and research activities of this technology in the most trends in many industrial and developed countries and developing countries. Because, economic and industrial future of the world will be seriously affected by nanotechnology as a revolution happening. This has been explained by scholars and researchers and became clear and definite for executive directors (Kohansal et al., 2015, Razeghi et al, 2013).

According to use of new methods, particularly nanotechnology in water treatment, and due to effective removal of contaminants and reduce costs of safe water production, the use of these technologies is considered more than older methods. Since none of the existing technologies could be assumed absolutely clean and safe, so, besides production targets, environmental aspects and potential sources of harm should be noted (Mondal and Ranil, 2008). Biochemical Oxygen Demand (BOD) is defined as the amount of dissolved oxygen needed by aerobic biological organisms in a given water sample. If BOD is low, the water is clean and free from the organism, or the organisms in the water were dead and do not need oxygen. In other words, it can be mentioned that BOD is the amount of oxygen needed for biological stability in water. The size of biological wastewater treatment plants, especially the amount of Wastewater aeration in aeration ponds, can be calculated according to the biochemical oxidation. If BOD is 1 ppm, it is almost pure water. A water supply with a BOD level up to 5 ppm is assumed to be relatively pure and when biochemical oxidation reaches more than 5 ppm, water purity is questionable. If the biochemical oxygen demand exceeds 20 ppm, public health will be at risk.

In recent decades, the use of various methods and tools for the removal of contaminants in wastewater has attracted many scientists and water resources researchers. So, the use of different methods and the combination of different methods with each other is considered by the researchers all around the world. Considering that Iran is located in arid and semi-arid region of the world, there has been a lot of planning and investment in this field during recent years (Kohansal, 2014). Biochemical oxidation tests provide realistic estimates of the quality of oxygen injected into the water. In order to measure biochemical oxidation, two bottles of water samples are filled. The amount of DO on of them is measured, then the lid of the other bottle is closed and placed within the same flow of water for 5 days (to maintain environmental conditions such as temperature, time and light). After 5 days, the DO is measured in the second one, and the difference in DO in the first and second containers indicates the BOD5 (5 is 5-day biochemical oxidation) (Kohansal, 2014).

In recent decades, the use of various methods and tools for the removal of contaminants in wastewater has attracted many scientists and water resources researchers. So, the use of different methods and the combination of different methods with each other is considered by the researchers all around the world. Considering that Iran is located in arid and semi-arid region of the world, there has been a lot of planning and investment in this field during recent years (Kohansal, 2014). Biochemical oxidation indicates the amount of microorganisms in the wastewater. The higher the amount of microorganisms, the more oxygen is consumed. More oxygen in water causes disruption of aquatic life and difficulty in agriculture and industry. Biochemical oxidation indicates the amount of microorganisms in the wastewater. The higher the amount of microorganisms, the more oxygen is consumed. More oxygen in water causes disruption of aquatic life and difficulty in agriculture and industry.

Due to importance of waste water treatment and also nano-filtration during recent years, substantial research has focused on this area. Eslamian et al. (2011) studied the use of treated wastewaters for different purposes. They collected wastewater of factories in the north of Isfahan, then, used them for Firefighting organization, cooling towers and boilers after advanced treatment of wastewaters. Kheirkhah et al. (2012) compared Nano Filtration Method methods with other old methods and showed that Nano Filtration Method is not only better than the old methods for the removal of harmful substances, but, it is more economical. Daei nia et al. (2012) studied the

effectiveness of Nano Filtration technology for the removal of three metals; nickel, zinc and copper as an indicator of heavy metals in industrial wastewater. The Aim of This Study was to evaluate three factors; pressure, concentration and time on the removal of heavy metals using a Nano Filtration membrane. Their results showed that the removal rate increased with increasing the pressure, and it decreased with increasing concentration and time was evaluated as a positive factor for increasing the removal rate. Lopez et al. (2005) investigated Nanofiltration method to remove COD and color in textile industry and showed the efficiency of NF for the retention of dyes, COD and color present in textile wastewaters.

According to Produced wastewater during oil and gas manufacturing is the largest source of non-conventional oily waters. Mondal et al (2008) tested this non-conventional source with two nano-filtrations and a low-pressure reverse osmosis in Colorado, USA. Their results presented that treatment using nanotechnology developed using this method for non-conventional water resources. Hassani et al. (2008) studied dye removal rate including four different feed types of dyes (Acidic, Disperse, Reactive and Direct) by nanofiltration membrane and showed the high dye removal efficiency (98 %). Liu et al. (2011) evaluated and compared reverse osmosis (RO) and nanofiltration (NF) to remove COD for a textile effluent treatment and showed NF can be used efficiently to treat textile effluent at low pressure and less fouling.

Wu et al. (2012) performed a test to determine the effect of nano-filtration on COD, ammonia, color, concentration, pH, temperature, and etc. Their test results showed that the color has vanished to 99% and did not depend on other factors and other items such as control and Ammonium removal has been variable from 83% to 90% according to other agents. They showed by GC-MS analysis that the majority of organic compounds in the industrial wastewater was removed by NF membrane. Shon et al. (2013) studied the principles and mechanisms, challenges of deposition (desalination), and controlling them to use of Nano Filters to pay wastewater treatment. Abdel-Fatah (2018) studied NF technique for a variety of water and wastewater treatment in different industrial applications. The aim of this research was the removal of ions and organic substances and reviewed the main applications of NF in water and wastewater reuse. Jang et al. (2018) used Nnanofiltration to reduce COD and color of waste soy souce and the results showed it's one of the best treatment method which resulted in 98.1% color removal and 98.2% COD reduction.

2. Materials and Methods

2.1 Industrial wastewater treatment

Wastewater needs to be improved prior to reintroduction to the environment. Wastewater collected either from population centers or factories should be returned eventually to the water or soil. Entering wastewater without modification and treatment to soil and water resources will cause environmental problems. Industrial Wastewaters are not the exception and need to be treated in order to reuse or return to the environment. In general, wastewater treatment methods can be divided into three main categories: physical, chemical and biological. It rarely happens that one of the described methods can meet all the demands of the treatment system. So, in most cases it is mostly necessary to use a combination of the above-explained methods (Eslamian and Tarkesh, 2013).

2.2 Nanotechnology and industrial wastewater treatment

By applying electrical and mechanical technologies, previously polluted water can be used for agriculture, industrial and municipal applications. Water filter by nanometer filters has created dramatic change in recycling and reuse of water in industrial, agricultural and municipal sectors. Physical filters with micrometer and Nanometer-Scale Pores could fully screen bacteria, viruses and even the small units of proteins. Salts and heavy materials can be absorbed through the electrical separators that absorb ions using super capacitor plates. Studying different activities in the world, including ongoing programs and future plans of industrial and research center shows that the treatment is one of the areas of application of nanotechnology in the water industry. The applications of nanotechnology in water treatment are included the following:

- Nano-filtration
- Nanotech sensor
- Sweeteners made from nanometer membrane
- Water treatment using nano-particles
- Wastewater Treatments
- industrial Wastewater Treatment
- Mercury removal

2.3 Nano-filtration

Nano-filtration technique has flourished over the last few years. Separation is based on molecular size in nano-filtration and it is a compression process. This method is used to remove organic pollutants such as polyvalent ions and micro pollutants. Other applications of nano-filtration can be included: removal of chemicals that have been added to water to kill harmful organisms, heavy metals removal, water treatment, decolonization, Pollution Removal and Nitrate Removal. Nano-filtration could produce clean water from almost any source of water and remove all the bacteria in the water. Also, it provides easy to use treatment methods. By using nano-filters, minerals needed for human health are remained in the water and Toxic and hazardous substances are removed (Kohansal, 2014).

Scientists and researchers have found simple method for producing filters using carbon nanotubes that in addition to effective removal of pollutants in micro and nano-scale from water resource also can separate heavy hydrocarbons from crude Oil. The use of carbon nanotubes to make filters enable ease of cleanup, increase the strength, reusability and heat resistance. These filters are very accurate and able to remove 25 nm viruses, as well as larger pathogens such as coliform bacteria E-Cola from water. Cost reduction and Controlling the amount of pollution in treated water is considered as other advantages of using this method.

2.4 The Study Area

The treatment plant is located on the northern side of Najafabad Industrial city. The type of treatment process is MBBR+UAFBR. The capacity of the treatment plant in the first module is 310 cubic meters per day. The source of wastewater is from industrial factories of the industrial zone and also urban wastewater around the zone.

2.5 Characteristics of Filters and Pilot

The main filter is the type of nano tube filter with small holes at the Nano-Scale, the combination of carbon and neon. Water entry is from side and its exit is from the middle of filters to the downside. The filter has diameter of 3 cm, a thickness of 5 mm, a height of 30 cm and pore diameter of 50-80 nm Filter is designed such that Microorganisms and bacteria can also be filtered and treated. Optimal operating pressure is 10 times, although it works in 6 times.

2.6 Methodology

The experiments were performed 11 weeks and 11 replicates. Samples were harvested on a weekly basis, on Tuesday and from control and two treatments. At the same time, the experiments were performed to reduce the error rate. In order to avoid excessive rise of pressure in nanofilter pilot, the filters were washed (in case of excessive rise of pressure). The input of the nanofilter and the treatment plant was the same to avoid additional testing. After obtaining the results, the percentage of removal of BOD5 was calculated and the results were analyzed statistically. The comparison was done between the two tested methods in terms of removal rate and percentage.

2.7 The used software

In this study, the data are entered in the Excel 2010 software and the removal percentage of various parameters has been calculated. Also, the required graphs are drawn by this software. Then, SPSS software was used to determine meaningfulness of percentage difference. Due to the existence of two independent data sets for each parameter, including the amount of wastewater by nanofiltration and biological methods, The T-Method was used for two independent samples. The average of two methods for each parameter is calculated by this software. Then, a significant amount is considered for each parameter. If the value is greater than 0.05, the significant level written in the upper row, and if it is less than 0.05, the level written in the lower row is considered. If the level of significance is less than 0.05, then there is a significant difference at the level of 5% but if there is more (than 0.05), there will be no significant difference.

The aim of this study was to compare treated industrial wastewater using biological method compared to the nanofiltration method and determine the most appropriate method for industrial wastewater treatment. The main innovation of this research is the use of nanofiltration that was designed and used for the first time. Using the magnet filter along with other filters is also an innovation of this project. Meanwhile, comparison of nanofilter treatment with the biological method used in this treatment plant can be another innovation. The capacity of treatment plants in the first module is 310 cubic meters (m^3) per day. The defined input parameters, the anaerobic removal percentage, and the value of the defined output parameters are shown in Table 2. Alternative tube filter is also considered which is made from neon and carbon. But the difference is in the diameter of the filter and stomata diameter and the operating pressure.

Measuring BOD5 requires more time than other parameters because the sample should remain inside the incubator for 5 days. This parameter was measured by the BOD meter of the AL606 model manufactured by the Aqualite Corporation of Germany. This device, as in Figure 1, should be placed inside the incubator.

Table 1: The amount of wastewater contaminants removal in designing of Najafabad treatment plant 1.

Parameters (mg/L)	*the amount of input* (mg/L)	Anaerobic removal percentage (%)	The amount of output (aerobic)
TSS	640	30	50-20
COD	1390	50	50-20
BOD_5	480	60	20-80
Q	310 cubic meters per day		

Table 2: The characteristics of the main nano-filter and alternative microfilters.

	Material	Diameter (cm)	Thickness (cm)	Height (cm)	stomata diameter	Optimal operating Pressure	Minimum operating Pressure
Main Nanofilter	Carbon-Neon	3	0.5	30	50-80 Nanometer	10 bar	6 bar
Alternative Nanofilter	Carbon-Neon fiber	10	3	30	1-2 Micrometer	3 bar	1 bar

Figure 1: The placement of BOD meter.

3. Results

Experiments were completed on raw wastewater, nano-filtrate effluent and biological wastewater after 11 weeks and the results of nano-filtrate and biological effluent experiments in terms of quantity and Percentage of removal is presented in a table and a chart is drawn up for further explanation. These results are presented in detail below.

According to table 3, although the biological system has a good performance on this parameter and has been able to reduce this parameter well, the nanofiltration system has a better performance than the biological system. This is justified due to being antibacterial of the used nanofilter. It is noteworthy that the BOD5 (wastewater) of Nano-Filtration System is approximately equal in all experiments. This causes to trust this system as a reliable system in reducing BOD5. The output of biological wastewater has similar conditions but less than the nanofiltration which indicates that this system also has a high ability to wastewater treatment.

Table 3: The results obtained from BOD5 experiments on raw wastewater.

Expriment No	BOD_5 (mg/lit)			BOD5 reduction percentage	
	Raw Watewater	NanoPilot wastewater	Biological wastewater	NanoPilot wastewate	Biological wastewater
1	76.00	7.20	12.00	90.53	84.21
2	76.00	7.10	10.00	90.66	86.84
3	68.00	6.50	11.00	90.44	83.82
4	72.00	6.90	8.00	90.42	88.89
5	75.00	7.00	8.00	90.67	89.33
6	70.00	6.80	6.00	90.29	91.43
7	81.00	7.10	15.00	91.23	81.48
8	65.00	6.50	8.00	90.00	87.69
9	70.00	6.80	9.00	90.29	87.14
10	73.00	6.80	12.00	90.68	83.56
11	74.00	6.90	10.00	90.68	86.49

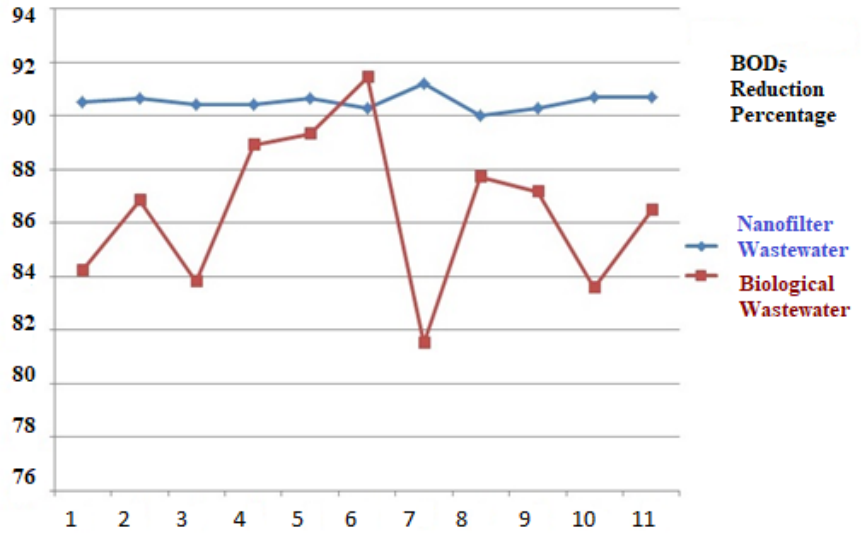


Figure 2: Comparison of BOD5 reduction percentage of wastewater samples.

Another point that is shown in Figure 2 is experiment No. 6. In this experiment, the biological system has been more efficient than the nanofiltration system. Due to the relatively high oscillation of biological treatment efficiency on BOD5, the study of the reason for the greater efficiency of this system in Test No. 6 can be a very interesting issue. Studying the reason for more efficiently of the system in Test No. 6 can be an interesting topic which may be due to the low BOD5 in the raw wastewater and the youthfulness of the biological system's sludge on this day. SPSS software results also showed a significant difference in the level of 5% between the two methods. This is, as shown in table 4, is proved because of less than 0/05 level of significance for this parameter. Mean of 6.87 mg / L for nanofiltration method and 9.91 mg / L for biological method shows both methods have a great ability to reduce this parameter, but the significance of the difference is more in the nanofiltration method.

Table 4: T-test results for the test parameters.

Parameter	Method	Mean	F	Sig.	df	The significance level	Significance of Difference
BOD_5	Nanofiltration method	6.87	14.74	0.00	20.00	0.001	✓
	Biological Method	9.91			10.17	0.002	

4. Conclusions and Recommendations

According to the results of this study, it can be concluded that the used nanofilter method has a high efficiency to remove or reduce BOD5 and the outlet wastewater was at the level of drinking water. Nanofilter system not only has a good competition with the biological system, but also showed better performance in most experiments. Only in one experiment, the removal percentage was lower than the biological system. This shows that the nano-filter system could be a good alternative to the biological system.

It should be noted that the main efficiency of the biological system is on BOD5 which the existing biological system has been able to reduce BOD5 to an acceptable level. Although many some researches show that the nanofiltration system does not have the ability to reduce BOD5, but the experiments showed quite the opposite. Therefore, it can be concluded that the used nanofilter system is a reliable system for reducing BOD5. Meanwhile, the disadvantages of nanofiltration method include the need for high energy for wastewater passing through the main filter and the high initial cost compared to outlet wastewater volume.

The advantages of nanofiltration also include lack of requirement to retention time, rapid treatment, high efficiency in removal of water pollutants and low dependence on parameter value in raw wastewater (inlet). Other parameters such as heavy metals, iron compounds and other parameters that are not measured are measured and evaluated to determine the efficiency of the nano-filter to remove and reduce other parameters from wastewater. Wastewater with higher and lower level of contamination should be investigated in order to determine more appropriate and optimal range for using the nanofiltration system. The use of combination methods is highly recommended. In other words, instead of entering raw wastewater into a nano-filtrate, the raw wastewater should be initially treated with a simple and inexpensive method and the outlet will enter into the nanofilter system. This can reduce times of filter washing and reduce costs significantly. Also, higher efficiencies can be achieved in wastewater treatment, and wastewater is produced with better quality.

References

Abdel-Fatah, M. A (2018). Nanofiltration systems and applications in wastewater treatment: Review article, Ain Shams Engineering Journalm, 9(4).

Daei Niaki SM, Takdastan A, Zazouli MA, Seddigh Mortazavi M (2012). Application of Nanofiltration Technology in Heavy Metals (Ni, Cu and Zn) Removal from Wastewater. WWWJ (1):125-131.

Eslamian, S. S., Tarkesh Esfahani S (2011). Water Reuse (Urban Waste Water Application), Arkan Danesh Publishing, Isfahan, Iran, 327 Pages.

Jang, H.H., Seo, G.T and D.W Jeong (2018). Advanced Oxidation Processes and Nanofiltration to Reduce the Color and Chemical Oxygen Demand of Waste Soy Sauce. Sustainability, 10(8), p.2929.

Hassani, A. H., Mirzayee, R., Nasseri, S., Borghei, M., Gholami, M., & Torabifar, B. (2008). Nanofiltration process on dye removal

from simulated textile wastewater. International journal of environmental science & technology, 5(3), 401-408.
Kheirkhah, R.K., Fakharian A., Ghadirian, M. (2012). Evaluation and use Nanotechnology in Iranian water treatment plant, International Magazine of water and sewer facilities - Omran-e-Ab; 15 no.
Kohansal, M. M. (2014). Industrial Wastewater Treatment Using Nano-filter in Comparison with Biological Method for Agricultural, Landscape and Industrial Purposes, (MSc. Thesis), Isfahan University of Technology, Retrieved from http://ganj.irandoc.ac.ir/articles/798947.
Kohansal, M.M., S. Saadati, S.T. Esfahany and S. Eslamian (2015). Urban Water Reuse in Industry. In: Urban Water Reuse Handbook, Eslamian, S. (Ed.). Chapter 11, CRC Press/Taylor and Francis Group, USA. ISBN-13: 9781482229158, pp: 137-148.
Liu, M., Lü, Z., Chen, Z., Yu, S., Gao, C. (2011). Comparison of reverse osmosis and nanofiltration membranes in the treatment of biologically treated textile effluent for water reuse. Desalination, 281, 372-378.
Lopes, C.N., Petrus, J.C.C., Riella, H.G. (2005). Color and COD retention by nanofiltration membranes. Desalination 172, 77–83.
Mohamadi, O., Heidarpour, M., Kohansal, M.M. (2014). Evaluation of the BOD and Phosphorus removal in industrial wastewater using anaerobic - aerobic treatment, The 4th International Conference on Environmental Challenges & Dendrochronologoy, Iran, Sari.
Mondal, S., Ranil W.S. (2008). Produced water treatment by nanofiltration and reverse osmosis membranes. Journal of Membrane Science, 322 (1), 162-170.
Razeghi, N., Mansouri, R., Rouhani, P. (2013). Water Reuse (Planning and Programming), Moalef Publishing.
Shon, H.K., Phuntsho, S., Chaudhary, D.S., Vigneswaran, S., Cho, J. (2013). Nanofiltration for water and wastewater treatment – a mini review. Drink. Water Eng. Sci., 6, 47-53.
Wu, T.Y., Mohammad, A.W., Anuar, N., Rahman, R. A. (2002). Potential use of nanofiltration membrane in treatment of wastewater from fish and surimi industries. Songklanakarin J. Sci. Technol. 24 (suppl.): 977–987.