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The Study of Groundwater Treatment by Household Reverse Osmosis System

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Abstract: ***Water desalination systems; especially household reverse osmosis; have become widely used in Iraqi homes due to lack of water that conforms to the global standards of drinking water in recent times. The ability of RO system to treat groundwater has been tested within a period of time. Water samples have been analyzed before and after entering the system for physical, chemical and biological parameters. The results showed that the RO system was efficient in removal different types of contaminants; and the removal efficiency was as follows: Electrical Conductivity (EC) (92.9%); Turbidity (78.5%); Total Hardness (T.H) (96.8%); Calcium (Ca) (97.1%); Magnesium (Mg) (96.4%); Sulfate (So4) (92.2%); Nitrate (No3) (92%); Sodium (Na) (91.6%); Potassium (K) (84.9%); Chloride (Cl); Bicarbonate (Hco3) (87.7%); Cadmium (Cd) (100%); Iron (Fe) (80%); Lead (Pb) (100%). The biological results showed that the ability of RO system to decrease the numbers of different types of bacteria. From these results; the Ro system was efficient in treating groundwater.***

Keywords: reverse osmosis, activated carbon, ground water

1. Introduction

Groundwater is an important resource for water that use for drinking, agriculture, industry, domestic services and others [1]. In last years and due to the rapid growth of population and shortage of fresh water resource; a great decline in groundwater quality has been occurring [2]. It is estimated that approximately more than half the world's population depends on groundwater for survival and one third of the world's population uses groundwater for drinking purposes [3]. Thus, in order to maintain an adequate supply of healthy and clean drinking water, the groundwater recourses must be carefully developed and managed [4].

Recently, membrane technology acquired a great attention in water treatment. Reverse osmosis used for water and waste water treatment as it efficient in removing dissolved and particulate contaminants, including, disinfection by-product precursors, total dissolved solids, hardness organic compounds and pathogenic microorganisms. [5] Reverse osmosis: is the process by which an applied pressure more than the osmotic pressure is applied on the partition that contained the highest concentration solution. So that water passes through the membrane in the opposite direction to that of osmosis from the high-concentration solution side to that with the low concentration solution. Hence, the water in the one compartment is purified or "demineralized" and the solids in the other compartment are concentrated or dewatered [6].

2. RO System Characteristics

The type of Ro system that used in this study contain seven stages as follow: 1. Sediment filter that used to remove particulate matter such as clay, silt, suspended solids, biological slime, algae, silica and other suspended matter that may adversely damage the RO membrane [7]. 2. Granular Activated Carbon: reduce bacterial contamination; organic chemicals of low molecular weight such as pesticides, herbicides, and industrial solvents. [8,9] 3. Block Carbon Filter: It is used for taste and odor control and also effective in removing the organic precursors that react with chlorine to form harmful THM compounds after disinfection [10]. 4. The RO membrane: It has a pore size around 0.0001 microns that is able to remove all organic molecules and viruses and most minerals and monovalent ions, which means that it desalinates the water [11]. 5. Post carbon filter: remove compounds that cause unpleasant taste and odors, including those from the tank, plastic tubing or any leftover chemicals just before the water is distributed [12]. 6. Grancal post filter: it is made from natural healthy source of granulate calcium, magnesium and carbon that's provided a balanced pH adjustment to prevent acid water corrosion and returning the beneficial minerals calcium and magnesium to the drinking water [13]. 7. Ultra Violet stage: it ensures product water free from microbial contamination.

3. Materials and Methods

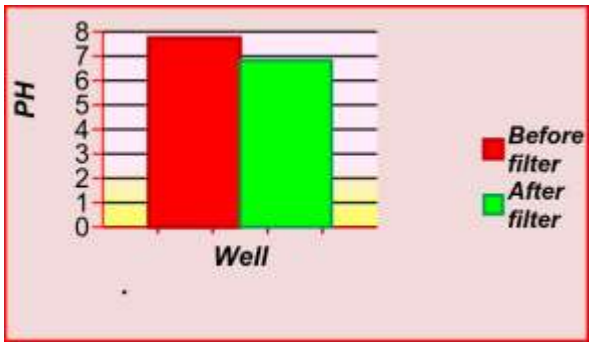
Water samples collected from well water located in AL-Ghazalia city within Baghdad/Iraq; about nine meters below the earth's surface during March_ April_May / 2017. 25 liters of water taken from the well in a plastic container and passed through the Reverse osmosis system in the laboratory. Water samples for physical and chemical analysis collected in polyethylene containers with a volume of 1 liter from the inlet and product water and kept cool until analyzed it. Water samples for biological analysis collected from inlet and product water in glass bottles washed with distilled water and sterilized in autoclave for one hour, then kept cool until analyzed it.

Water samples before and after treatment with the RO system were analyzed for: PH, Ec, Turbidity, TDS, Ca, Mg, So4, No3, T.H, Hco3, Cl, Na and k. In addition to the measurement of some heavy metals includes: Fe, Pb and Cd. The microbial analysis includes: total coliform, faecal coliform, total streptococcus, faecal streptococcus. PH was measured by PH-meter 315i/SET/WTW/ Germany. Electrical conductivity was measured by EC meter 330i/ST/ WTW/ Germany. Turbidity was measured by Turbidity meter Lovibond /Turbi check. TDS was measured by

filtration method. Cl was measured by titration with (AgNO3). NO3 and SO4 were measured by Ultraviolet Spectrophotometric Screening Method. T.H and Ca were measured by titration with 0.01N EDTA. Mg was measured by the difference between total hardness and calcium hardness. HCO3 was measured by titration with H2SO4. Na and K were measured by the flame photometric method. Heavy metals were measured by flame atomic absorption spectrometry (FAAS). The Most Probal Number was the method that used to examine the microbial contamination of water samples using MacConkey broth and Azide dextrose broth [14].

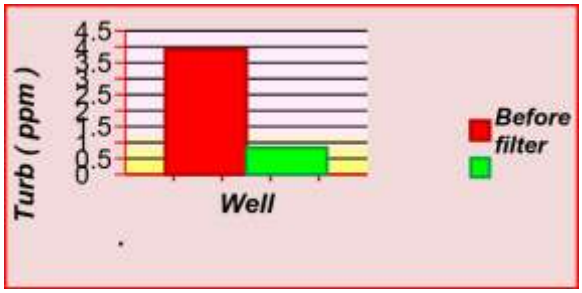
4. Result and Discussion

PH: The average value of inlet water was (7.74) and product water was (6.82). The reduction in PH value of product water is attributed to the ability of RO membrane to remove dissolved ions such as carbonates, but does not remove gases like carbon dioxide, which is converted into carbonic acid and decreased the value of PH [15].

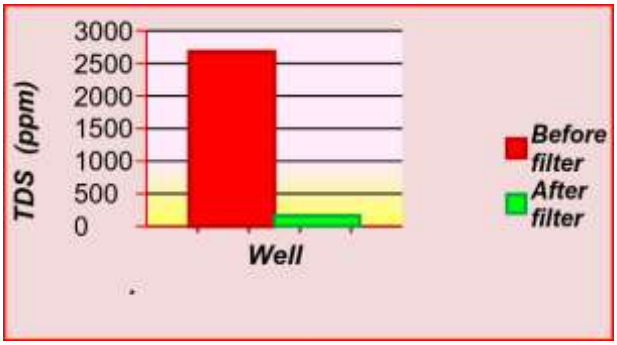


Electrical Conductivity (EC): The high concentration of (EC) gives water unpleasant odor and taste [16]. The removal efficiency was (92.9%) with an average concentration of inlet water (4526 Us/cm) and product water (318.88 Us/cm).

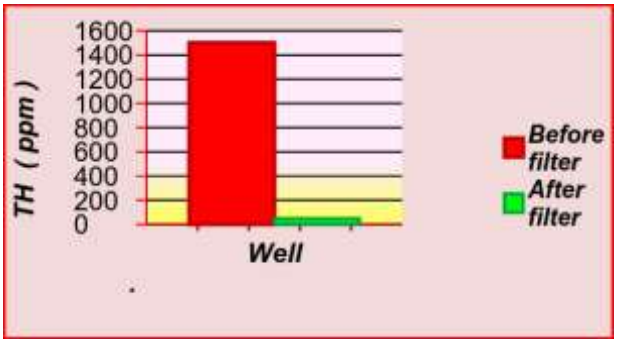
Turbidity: The removal efficiency was (78.5%) with an average concentration of inlet water (3.9 NTU) and product water (0.84 NTU). The level of turbidity can be removed by sediment filter.



Total Dissolved Solids (TDS): The removal efficiency was (93.8%) with an average concentration of inlet water (2679.32 ppm) and product water (164 ppm).

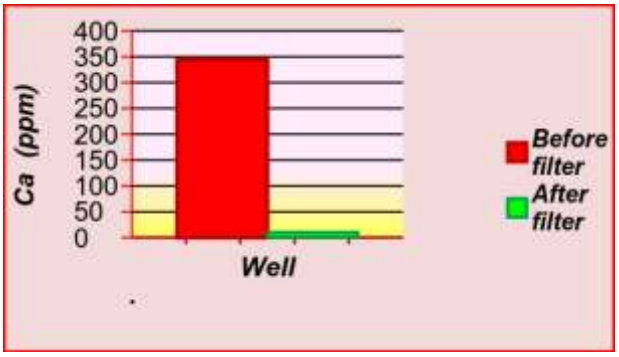


Total Hardness (T.H): The removal efficiency was (96.8%) with an average concentration of inlet water (1500 ppm) and product water (48 ppm). Reverse Osmosis membrane is able to reduce water hardness, but the high level of hardness can adversely affect RO membrane and reduce its life as it is quickly fouled by hard water. Therefore, pre-filter must be used such as activated carbon filter to protect the RO membrane [17].



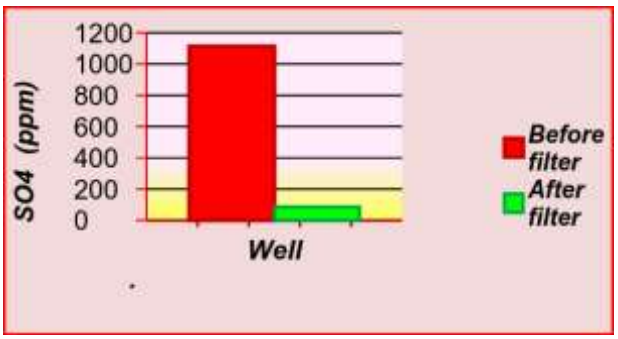
All the above results agree with [18] who found that the removal efficiency of RO system were (96.68% to 100%).

Calcium (Ca): The removal efficiency was (97.1%) with an average concentration of inlet water (344 ppm) and product water (9.96 ppm).

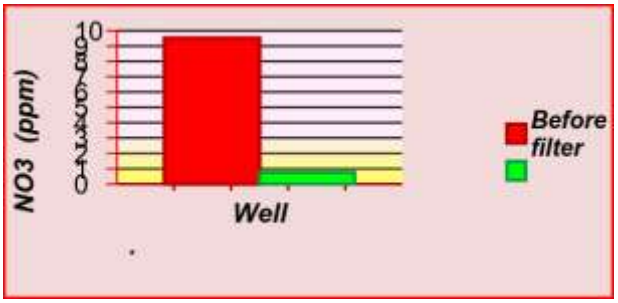


Magnesium (Mg): High level of (Mg) in drinking water cause a laxative effect; and when its concentration in plasma reach to 15 meq/l cause respiratory depression, skeletal muscle paralysis, coma, and death [19]. The removal efficiency was (96.4%) with an average concentration of inlet water (155.6 ppm) and product water (5.56 ppm). The low concentration of Ca, Mg and total hardness in RO water attributed to the process of desalinization which removes the minerals from the raw water [20].

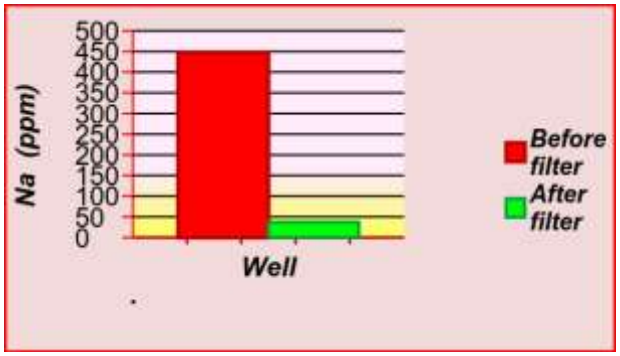
Sulfate (SO_4): The removal efficiency was (92.2%) with an average concentration of inlet water (1114 ppm) and product water (86.22 ppm). The higher removal rate of sulfate because the divalent species are strongly rejected by the RO membrane [21].



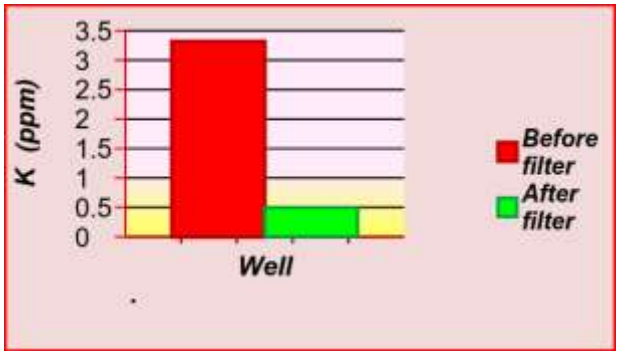
Nitrate (NO_3): is a stable negatively charged ion and highly soluble in water. It is considered one of the most common contaminants in surface and groundwater; adverse health effects could be occur when people consume water that contain high concentrations of nitrate [22]. The removal efficiency was (92%) with an average concentration of inlet water (9.51 ppm) and product water (0.76 ppm).



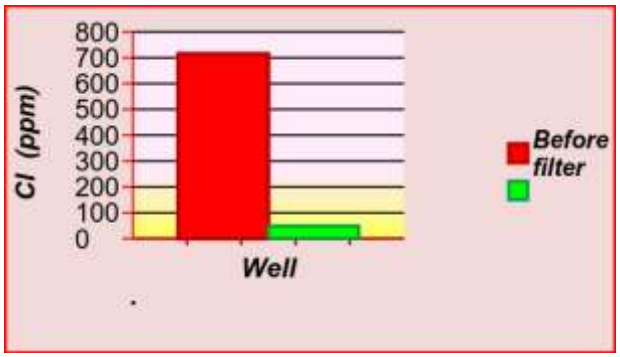
Sodium (Na): High concentration of (Na) in drinking water can result in increased its level in blood serum and lead to high blood pressure that causes damage to body organs, especially to the heart and arteries, heart attack and stroke [23]. The removal efficiency was (91.6%) with an average concentration of inlet water (447 ppm) and of product water (37.32 ppm).



Potassium (K): The removal efficiency was (84.9%) with an average concentration of inlet water (3.32 ppm) and product water (0.5 ppm).

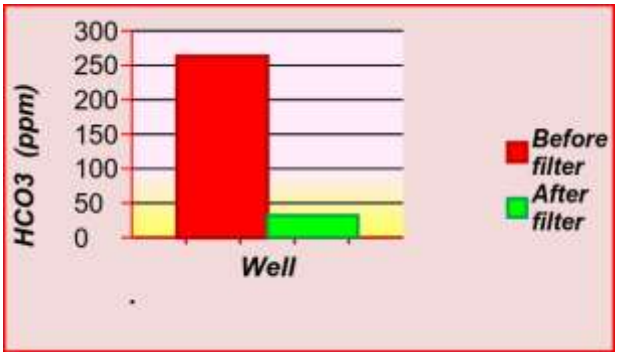


Chloride (Cl): The removal efficiency was with an average concentration of inlet water (715 ppm) and product water (49 ppm).

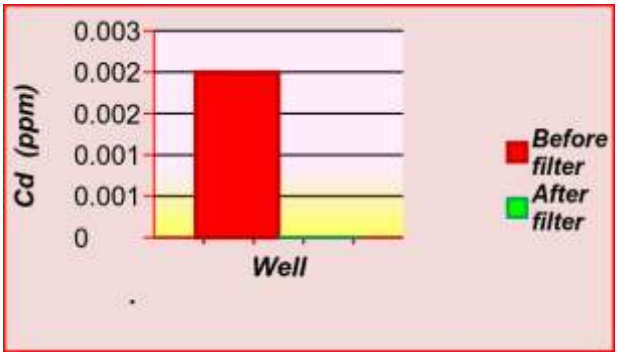


Bicarbonate (HCO_3): The removal efficiency was (87.7%) with an average concentration of inlet water (263.02 ppm) and product water (32.16 ppm).

These results agree with [24] who found that all chemical analyses of product water are within the allowable WHO limits.

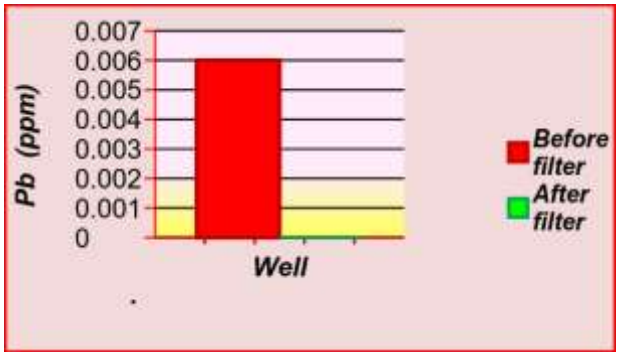


Cadmium (Cd): The ingestion of contaminated fish or drink water contain a small amount of cadmium can result in renal dysfunction, skeletal deformation [25]. The removal efficiency of (Cd) reached to (100%) with an average concentration of inlet water was (0.002 ppm) and product water (Zero ppm).



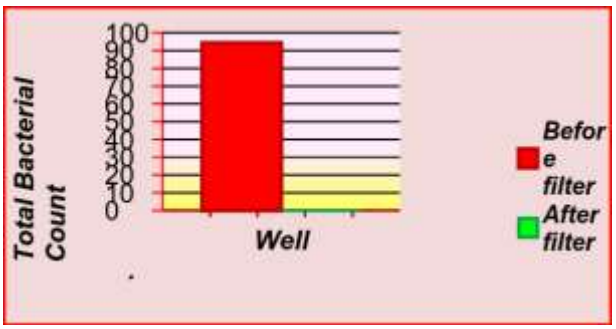
15. Iron (Fe): The removal efficiency of (Fe) was (80%) with an average concentration of inlet water (0.03 ppm) and product water (0.006 ppm).

Lead (Pb): High concentration of Pb cause harmful effect to the human body, such as muscle weakness, vomiting, nausea, birth defects, kidney damage and learning difficulties [26]. The removal efficiency of (Pb) was (100%) with an average concentration of inlet water (0.006 ppm) and product water (Zero ppm).

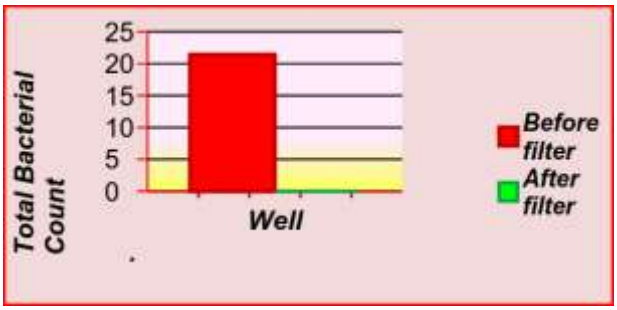


The results of heavy metals agree with [27-28].

Total Coliform (TC): The results indicate that the number of (TC) ranged from 35 to 161 CFU/100ml in inlet water with an average of 94.4 CFU/100ml, and filtered water was without any bacterial growth.



Fecal coliform (FC): The number of (FC) ranged from 11 to 43 CFU/100ml in inlet water with an average of 21.4 CFU/100ml, and filtered water was free from any contamination.



Total streptococcus (TS): The number of (TS) ranged from 3 to 21 CFU/100ml in inlet water with an average of 11.6 CFU/100ml, and filtered water was clear from any growth.

Fecal Streptococcus (FS): The number of (FS) ranged from 3 to 9 CFU/100ml in inlet water with an average of 5.6 CFU/100ml, and filtered water was free from any growth.

Statistical Analysis: All the results showed significant differences between groundwater and filter water except for Ni+.
All the results of filtered water are within the Iraqi standard for Drinking water quality and of World Health Organization standards.

Reverse Osmosis Membrane, Activated Carbon Filters and Ultraviolet Mechanism Of Removal

Polyamide RO membrane was used in this study with a pore size around 0.0001 microns. In reverse osmosis, the water moves from higher concentration to the lower one due to the applied pressure. Pure water passes through the membrane, thus, salts and the other substances in water, such as suspended particles, viruses, minerals, organic matter and microbes remains in the other side of the membrane [29].

AC preparation involves two main steps: the carbonization of the carbonaceous raw material at temperatures below 800°C in an inert atmosphere and the activation of the carbonized product. Thus, all carbonaceous materials can be converted into activated carbon [30]. The unique structure of AC provides a very large surface area and pore volume that gives it a unique adsorption capacity [31]. The attractive forces between the contaminant (non-polar) and the carbon surface (non-polar) and are stronger than the forces keeping the contaminant dissolved in water (polar) [32]. The application of AC in water treatment is mainly centered in the removal of pollutant organic compounds such as natural organic matter (NOM), odors, tastes, detergents, pesticides, trihalomethane and bacteria [33].

The Ultra Violet lamp is responsible in decreasing the numbers of contaminated bacteria. The mechanism of micro-organism destruction is currently believed to be due to the fact that ultraviolet causes molecular rearrangements in DNA and RNA, which in turn blocks replication [34].

5. Conclusion

The results of this study showed that the Reverse osmosis system was efficient in reducing the numbers of bacteria in groundwater and it was able removing all water contaminants with a high value. So this type of systems is recommended to treat groundwater contamination.

6. Acknowledgement

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References

[1] Papaioannou, A., Mavridou, A., Hadjichristodoulou, C., Papastergiou, P., Pappa, O., Dovriki, E., & Rigas, I. (2010). Application of multivariate statistical methods for groundwater physicochemical and biological quality assessment in the context of public health. *Environmental monitoring and assessment*, *170* (1), 87-97.
[2] Piscopo, G. (2001). Groundwater vulnerability map explanatory notes—Castlereagh Catchment. *NSW Department of Land and Water Conservation, Australia*.
[3] Mohrir A. Ramteke D.S.,Moghe C.A., Wate S.R. and Sarin R. (2002) Surface and Groundwater Quality Assessment in Binaregion", IJEP.Vol.22 (9).
[4] Gleick, P. H. (1996). Water resources. *Encyclopedia of climate and weather*, *2*, 817-823.
[5] Karakulski, K., Gryta, M., & Morawski, A. W. (2001). Pilot plant studies on the removal of trihalomethanes by composite reverse osmosis membranes. *Desalination*, *140* (3), 227-234.
[6] Kucera, J. (2015). *Reverse osmosis: design, processes, and applications for engineers*. John Wiley & Sons.
[7] El-Nashar, A. M. HISTORY AND CURRENT STATUS OF MEMBRANE DESALINATION PROCESSES.
[8] Haas, E. M. (2006). *Staying Healthy With Nutrition, 21st Century Edition: The Complete Guide to Diet & Nutritional Medicine*. Random House Digital, Inc.
[9] Ingram, C. (2006). *The Drinking Water Book: How to Eliminate the Most Harmful Toxins from Your Water*. Random House Digital, Inc.
[10] Spellman, F. R., & Drinan, J. (2012). *The drinking water handbook*. Boca Raton: CRC Press.
[11] Deokate, A. (2015). Development of Textile Waste Water Treatment Reactor to Obtain Drinking Water by Solar Powered Electro -Coagulation Technique . International Journal of Research in Environmental Science and Technology, 5 (1), 29-34.
[12] Kneen, B., Lemley, A., & Wagenet, L. (2005). Reverse Osmosis Treatment of Drinking Water. *Water conditioning and purification international*, *50*, 58.
[13] Grancal Disposable Filter Cartridge-Puricom. Available online: http://www.puricom.com/exec/product.php?mod=show&cid=69&pid=FT-0033-2&lg=E
[14] APHA, AWWA and WEF. (2012). Standard Methods for The Examination of Water And Wastewater. 22st edition. Washington, DC: American Public Health Association, American Water Works Association, Water Environment Federation.
[15] Duranceau, S. J. (2009). Desalination post-treatment considerations. *Florida Water Resources Journal*, 4-18.

[16] Walakira, P. (2011). *Impact of industrial effluents on water quality of receiving streams in Nakawa-Ntinda Uganda* (Doctoral dissertation, Makerere University).
[17] Benham, B. L., & Ling, E. (2013). Virginia Household Water Quality Program: Household Water Treatment.
[19] Canada. Water-magnesium
[20] Moyel, M. S., Amteghy, A. H., Naseer, T. K., Mahdi, E. A., Younus, B. M., & Albadran, M. A. Comparison of total hardness , calcium and magnesium concentrations in drinking water (RO), and municipal water with WHO and local authorities at Basrah province, Iraq.
[21] Bodalo-Santoyo, A., Gómez-Carrasco, J. L., Gomez-Gomez, E., Maximo-Martin, F., & Hidalgo-Montesinos, A. M. (2003). Application of reverse osmosis to reduce pollutants present in industrial wastewater. *Desalination*, *155* (2), 101-108.
[22] Luk, G. K., & Au-Yeung, W. C. (2002). Experimental investigation on the chemical reduction of nitrate from groundwater. *Advances in environmental research*, *6* (4), 441-453.
[23] Bradshaw, M. H., & Powell, G. M. (1994). Sodium in drinking water.
[24] Aish, A. M. (2011). Water quality evaluation of small scale desalination plants in the Gaza Strip, Palestine. Desalination and Water Treatment, 29(1-3), 164-173.
[25] Mishra, P. C. (2008). *Fundamentals of air and water pollution*. APH Publishing.
[26] Alluri, H. K., Ronda, S. R., Settalluri, V. S., Bondili, J. S., Suryanarayana, V., & Venkateshwar, P. (2007). Biosorption: An eco-friendly alternative for heavy metal removal. *African Journal of Biotechnology*, *6* (25).
[27] Pawlak, Z., Żak, S., & Zabłocki, L.(2006).Removal of Hazardous Metals from Groundwater by Reverse Osmosis. Polish Journal of Environmental Studies , 15(4).
[28] Khsaf, S. A. (2015). Study of Treatment Al-Shamia West Drainage Water to be Used for Drinking Purposes. Engineering and Technology Journal, Volume: 33 Issue: 4 Part (A) Engineering Pages: 47-55.
[29] Spiegler, K. S., & El-Sayed, Y. M. (1994). *Desalination primer*. Balaban Desalination Publication.
[30] Bansal, R. C., & Goyal, M. (2005). *Activated carbon adsorption*. CRC press.
[31] Baker FS, Miller CE, Repik AJ, Tolles ED. Activated carbon. In: Kirk-Othmer K, Editor. Kirk-Othmer Encyclopedia of Chemical Technology, A to Alkaloids. New Jersey, NJ: John Wiley & Sons; 1991. p. 1015-37.
[32] Inegbenebor, A. I., Inegbenebor, A. O., & Bayo, H. (2012). Comparison of the Adsorptive Capacity of Raw Materials in Malting Activated Carbon Filter for Purification of Polluted Water for Drinking . ARPN Journal of Science and Technology, 2(9), 754-760.
[33] Marsh, H., & Reinoso, F. R. (2006). Activated carbon. Elsevier. P 431.
[34] Eccleston, B. (1998). UV intensity levels affected by water quality. Water Technology, 21(5), 61-68.
[18] Belkacem, M., Bekhti, S., & Bensadok, K. (2007). Groundwater treatment by reverse osmosis . Desalination, 206(1-3), 100-106.