Journal of Engineering and Sustainable Development
http://jeasd.uomustansiriyah.edu.iq/index.php
https://doi.org/10.31272/jeasd.26.1.4

Vol. 26, No. 01, January 2022
ISSN 2520-0917

THE MEMBRANE DISTILLATION ABILITY TO REMOVE CALCIUM ION FROM DAIRY WASTEWATER

*Ali A. Hasan[1] Ali F. Hassoon[2] Aisha A. Ahmed[1]

1) Civil Engineering Department, College of Engineering, Mustansiriyah University, Baghdad, Iraq
2) Electrical Engineering Department, College of Engineering, Mustansiriyah University, Baghdad, Iraq

Received 8/2/2021 ***Accepted in revised form 12/9/2021*** ***Published 1/1/2022***

Abstract: In this research the membranes distillation were used to remove calcium ions from heavy sewers at dairy plants in Iraq. This method is easy to operate, easy to manage and has many economic benefits. A chemical treatment was carried out on it using alum as a coagulant, different tests achieved samples before and after passing MD, according to APHA, AWWA, WEF. The results showed that obtained in water treatment trust that has been manufactured and edited according to the characteristics of the water waste the interests of the dairy capacity of this method to remove the calcium ion to a certain extent it is when the concentration reaches the inside of this ion to 1428.57 mg per liter, where to start the composition of hydroxides of calcium responsible for pain. The optimal working temperature ranges from 20-22 ° C and the flow is around 0.66 kg.m-2.h-1, here was the result of a layer of plaster that led to clogged membrane and folding and was stopped for washing and cleaning.

Keywords:*Calicium: Flux: Membrane Distillation; Removal; Dairy Wastewater*

1. Introduction

Is a vital industry not only inIraq in particular, but all over the world. The methods are used for different treatment over time and the states are different, and there has been the use of membrane distillation (MD), to treat waste water, heavy interest from the industry to ease the burden on the environment. Human bones contain about 99% of calcium. This element mixes with other beads to form hard beads that give the body more strength. A small portion of the calcium will dissolve in the blood. Here are the bones in the human body, like the calcium bank. About us, the body will go to the bank in the event of a decrease in the concentration of calcium in the blood. On this basis, the blood must be supplemented with calcium through the diet.consumes large quantities of water to reach production, and it depends on the administration and other factors surrounding the factory, and it ranges from 2 to 6 cubic meters per ton of milk. [1,2]. This type of industry is characterized by the discharging wastewater of a white acidic nature with a high turbidity. Salts also have a major role in raising electrical conductivity. Also, it contains dissolved solids and was recorded in alkaline times due to the presence of bicarbonate. Also, higher carbon dioxide and lower chloride values were observed. It has been observed that the oxygen concentration is low due to the high concentration of organic matter, BOD and COD. This case indicates that these wastes are rich in inorganic nutrients such as nitrogen and phosphorous. On the other hand, it is rich in

**Corresponding Author*: ah4433881@gmail.com

proteins and fats in addition to MPN microorganisms. [3], note “Table 1”

Table 1. Illustrate the characteristics of dairy wastewater factories.

Chemical compositions	Synthetic Samples
COD (mg/l)	1000-3000
Nitrate (NO_3^-) (mg/l)	0.2-16
TP (mg/l)	18-27
Chloride (mg/l)	20-100
Sodium (Na^+) (mg/l)	50-750
Turbidity (NTU)	40-50
TSS (mg/l)	200-1200
TS (mg/l)	150-2500
TDS (mg/l)	150-450
EC (µ mhos/cm)	300-4000
pH	6.5-7.5
Temperature (°C)	25 – 35

Water is the dominant feature of the dairy waste products[2]. The waterdetachedfrom the milkmay contain significant amounts of organic milk products and minerals. In addition,attackof the plant results in caustic wastewater[4, 5].

2. The Treatment Process of Dairy Wastewater

Because of the many different economic and technical advantages of the membrane separation method, which made it superior to other methods of the same type, such as Membrane separation (MSP) processes, commonly used for wastewater treatment, consist of microfiltration (MF) [6] ultrafiltration (UF)[7] nanofiltration (NF)and reverse osmosis (RO)[8] electrodialysis (ED)[9], capacitivedeionization (CDI)[10]. The majority of these are pressure-driven and utilize pressure variationas the driving force.Using hydraulic pressurevariationas the mass transferlashingforce has its disadvantages. One of the most important weak-points of such pressure-driven membrane processes is the osmotic-pressure limitation (OPL), [11], especially in the case of brine desalination andhypersalinewastewaters through either RO or NF processes. Therefore, searching for a new water/wastewater alternative is of interest. For this reason and for these motives the idea came from the application of the insulation place and using without the need to generate pressure or add other finincail cost, the idea of using Membrane distillation (MD) [6-10]. Thie procedure could be present in a simple view. To impose the driving force across the MD membrane, the vacuum is also applied in the distillate side utilizing a vacuumpumpas shown in “Fig. 1”. The practical space pressure should be lesserthan the diffusionpressure of the volatile molecules to be separated from the feed (hot) solution. In thisdesign, compression also takes place outside of the membrane module [11].

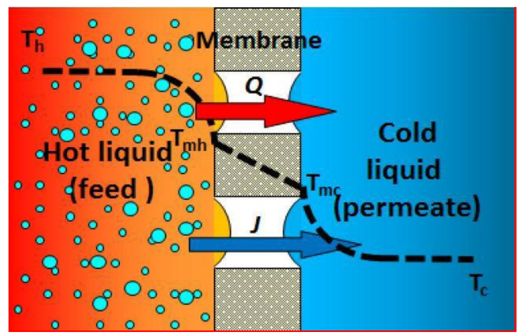

Figure 1. Basic principles of MD process (Shirazi and Kargari 2015).

3. The MD Process

This technology was mainly designed to operate withthe minimum external energyrequirements, the least capital and thesmallest possible implementation space. The feed temperatures in MD typically ranged from 35 to 85 ˚C.MD process is used because it does not require heating to boiling point and high operation pressure, so it requires less equipment and less cost.Hence, it can be said that this system is equivalent to other alternative energy systems such as solar energy, wind energy or geothermal energy with MD systems for energy-saving water desalination and water / wastewater treatment.In fact, harnessing solar energy to operate these reactors and produce pure water from salts and pollutants, made them stand out in the first places over their counterparts in mechanisms such as reverse osmosis and other membrane mechanisms. [11-14].

4. Pros and Cons of Membrane Distillation Process (MD) Over Other Techniques

This mechanism has extensive benefits in terms of exploiting the pressure teams generated by the temperature differential between the cold and hot surface of the robot body, which in turn will trigger the water molecules from the hot to cold surface, thereby reducing energy costs and less stringent mechanical characteristics. In contrast to distillation and RO, can be separated solutions supply at a much lower temperature than the boiling point and atmospheric pressure. Typical supply temperatures allow about 30-60 and perhaps 80 ° C to reuse residual heat flows and use alternative energy sources such as sun, wind and geothermal. It can be a very efficient and economical way of separating components that are suspended or dissolved in a liquid. It can reclaim valuable milk solids or chemicals for resale, reuse or less expensive method [15, 16].

4.1. Economic Technology of Membrane Distillation Process

- This process is simplest type of MD, has recently gained more attention.
- It can explain the characteristics of this type briefly [17-20]:

1- Total (100%) rejection,
2- Intensive to feed concentration,
3- Mild operating conditions,
4- Stable performance at high contaminant concentrations,
5- Osmosis characteristics play big role in achieving treatment.

5. Materials and Methods

To achieve this article it's has been used different tools and materials.

5.1. Setup:

A laboratory model has been built to achieve experiments, and the workflow in experimental implementation can be seen as shown in "Fig. 2

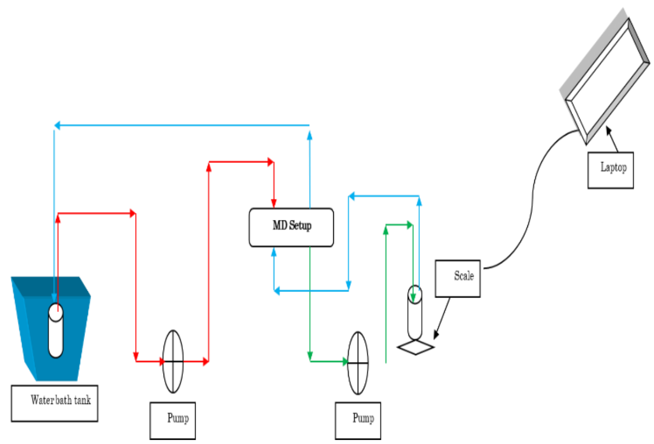

Figure 2 . Shows schematic diagram of setup used at the lab.

5.2. Synthetic Wastewater

Artificial samples were prepared similar to real samples discharged from dairy factories; these samples were prepared from salts below regarding to be similar real samples. From other hand alum were prepared each week to keep chemical characteristics of solution.

- Alum $Al_2(SO_4)_3.18$ added to 1 litre and used as solution in concentration 1% by adds 10 gm. to 1 litter of distilled water. This solution is remade every week to ensure its effectiveness.
- Sucrose hydrate $C_{12}H_{22}O_{11}.H_2O$
- Sodium Phosphate Dodecahydrate$Na_3PO_4.12H_2O$
- Ammonium sulfate$NH_4.2SO_4$

The above work was done as per standards [15].

5.3. Membrane Materials

The membrane used at this topic is PTFE part#: MSPTFE260045B, Lot#: 1801331008, pore size 0.45 μm, wettability: Hydrophobic, and this werer regarding to [22-24].

5.4. Equipment and Apparatuses:

The equipment's and apparatuses are stated below:

1. Turbid meter. Scale. Spectrophotometer. Dryer Oven. Glasses and pipettes, cones, flasks, filter papers, and other tools like tongs Blender …
2. EC, pH meter. **Total Nitrate meter.**
3. HCL acid and other chemicals like NaOH, tinctures sterile solutions ….Kaolin clay beside Alum and Calcium hydroxide, NaCl salt.

6. Results and Discussions

The main point that the calcium ion behaves is its attraction through the membrane like the sodium ion, although the ionic radius is close to or slightly smaller than the ionic radius of calcium.

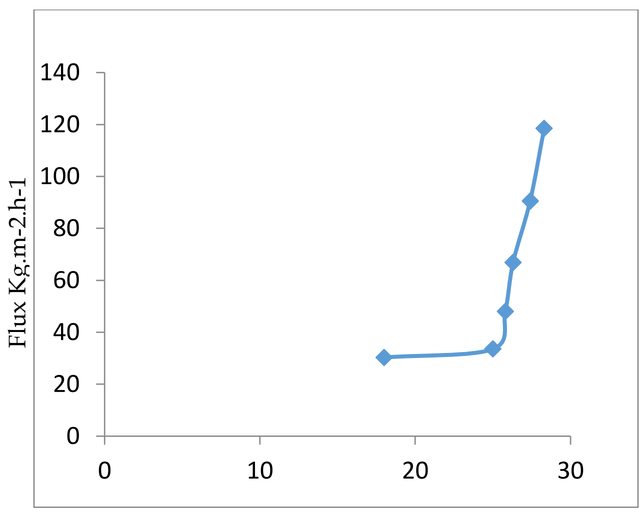

Figure 3. The figure showing the relationship between the flux and different temperatures.

This holes of the membrane means the volume of the pores which will pass vapour through the membrane in section. The retentate, which is the part of the supply that is not transient during the membrane pores, contains a high condensation of calcium. Mostly this stream is used back for higher effectiveness. As a result, removal of calcium will increase as the temperature of feed increase.

Note from "Fig. 3" that the loss of calcium ion concentration in the water treated with this mechanism increases with increasing temperature. In other words, increased membrane removal efficiency. This can be verified if "Fig. 4" is observed, with the remaining concentration decreasing in treated water with increasing temperature. This result can be explained by observing "Fig. 5", which indicates a decrease in calcium concentration with increasing temperature. To some extent this is achieved, so that the calcium ion has the ability to rush forcefully across the membrane by the pressure difference between the hot and cold surface. At the same time, the calcium ion can bond with calcium hydroxyl and calcium hydroxides that can focus on the surface of the membrane and form the plaster layer. It was observed from "Fig. 4" and confirmed by "Fig. 5" that it is more clear that the ideal temperature is 20 degrees Celsius, which is normal working conditions in the general environment.

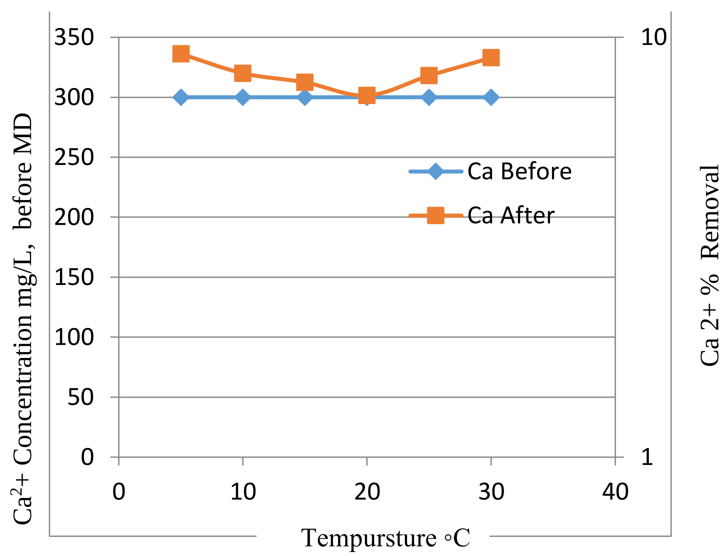

Figure 4. Logarithmic drawing shows the relation between Initial Ca^{2+-} and final concentration after pass samples through MD.

Here as can be seen from “Fig. 5”, percentage removal of calcium to 97.58 % at the same time and at a temperature of 20 °C will reach the 0.661 kg.m-2.h-1. Here it means that the calcium ion concentration in the membrane has reached saturation,

resulting in a concentration of the membrane, in this point the concentration of remaining calcium ion will be 7.264 mg/L. This case is a little positive, but it could bring back problems with the fouling. Therefore, it is observed at the temperature of 20 ° C in “Fig. 5” that the removal efficiency of the calcium ion will decrease and the flow begins to increase evidence of the occlusion of the membrane and the arrival of dirt and the imperative of washing to the membrane to re-work.

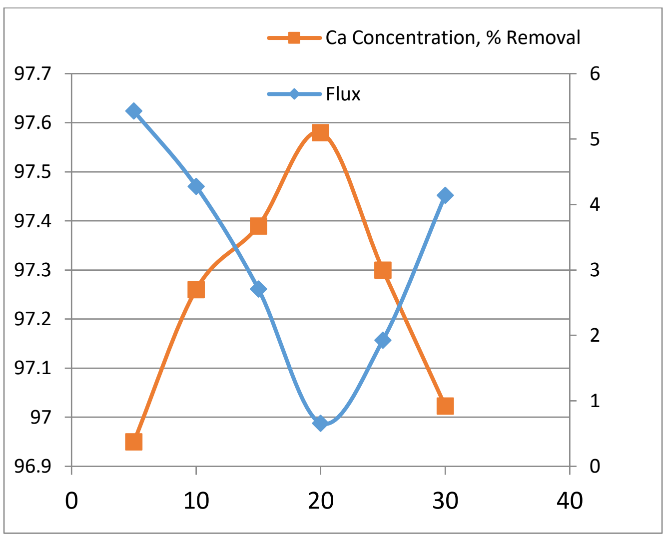

Figure 5.shows the relation between % removal of Ca^{2+}, Flux and temperature after pass samples through MD.

8. Conclusion

- The ability of the membrane mechanism to remove calcium to some extent is when the concentration of the interior is about 300 mg per liter, so the concentration of the outside of the membrane is equal to 7.264 mg/L and then the problems of folding begin to occur.
- The temperature is actively affecting the work mechanism. The perfect temperature for this work was 20 degrees Celsius.
- It is very significant to eliminate materials like organic and inorganic substances which may stop the membrane,
- The direction of flow promotional to the direction of connections affects on removal efficiency.

Acknowledgement

The author would like to thank the college of engineering and the laboratories of civil and environmental engineering in Iraq, for the support to achieve this article.

The author would like to thank RMIT University for help and support to achieve this article, as well as all working at the lab.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

9. References

1. Dorozhkin, S. V. (2007). "Calcium orthophosphates." Journal of materials science 42(4): 1061-1095.
2. Eliaz, N. and N. Metoki (2017). "Calcium phosphate bioceramics: a review of their history, structure, properties, coating technologies and biomedical applications." Materials 10(4): 334.
3. Tikariha, A. and O. Sahu (2014). "Study of characteristics and treatments of dairy industry waste water." Journal of applied & environmental microbiology 2(1): 16-22.

4. Amjad, Z. (2010). The science and technology of industrial water treatment, CRC press.
5. Arora, N. K., et al. (2018). "Environmental sustainability: challenges and viable solutions." Environmental Sustainability 1(4): 309-340.
6. Arola, K., et al. (2019). "Treatment options for nanofiltration and reverse osmosis concentrates from municipal wastewater treatment: A review." Critical Reviews in Environmental Science and Technology 49(22): 2049-2116.
7. Harto, C., et al. (2014). Saline water for power plant cooling: challenges and opportunities, Argonne National Lab.(ANL), Argonne, IL (United States).
8. Bolisetty, S., et al. (2019). "Sustainable technologies for water purification from heavy metals: review and analysis." Chemical Society Reviews 48(2): 463-487.
9. Gray, S., et al. (2018). Advanced Materials for Membrane Fabrication and Modification, CRC Press.
10. Shrivastava, B. K. (2016). "Technological Innovation in the Area of Drinking Water for Treatment of Saline Water." Asian Journal of Water, Environment and Pollution 13(3): 37-44.
11. Shirazi, M. M. A. and A. Kargari (2015). "A review on applications of membrane distillation (MD) process for wastewater treatment." J. Membr. Sci. Res 1: 101-112.
12. Lawson, K. W. and D. R. Lloyd (1997). "Membrane distillation." Journal of membrane Science**124**(1): 1-25.
13. Shirazi, M. M. A. and A. Kargari (2015). "A review on applications of membrane distillation (MD) process for wastewater treatment." J. Membr. Sci. Res**1**: 101-112.
14. Roy, S. and S. Ragunath (2018). "Emerging membrane technologies for water and energy sustainability: Future prospects, constraints and challenges." Energies**11**(11): 2997.
15. Nóbrega, J. A., et al. (2006). "Sample preparation in alkaline media." Spectrochimica Acta Part B: Atomic Spectroscopy**61**(5): 465-495.
16. Kang, G.-d. and Y.-m. Cao (2014). "Application and modification of poly (vinylidene fluoride)(PVDF) membranes–a review." Journal of membrane Science**463**: 145-165.
17. Wang, K. Y., et al. (2008). "Hydrophobic PVDF hollow fiber membranes with narrow pore size distribution and ultra-thin skin for the fresh water production through membrane distillation." Chemical Engineering Science**63**(9): 2587-2594.
18. Wang, J., et al. (2016). "Fabrication of hydrophobic flat sheet and hollow fiber membranes from PVDF and PVDF-CTFE for membrane distillation." Journal of Membrane Science**497**: 183-193.
19. Liu, F., et al. (2011). "Progress in the production and modification of PVDF membranes." Journal of Membrane Science**375**(1-2): 1-27.
20. Alkhudhiri, A., et al. (2012). "Membrane distillation: A comprehensive review." Desalination**287**: 2-18.
21. Khayet, M. (2011). "Membranes and theoretical modeling of membrane distillation: a review." Advances in colloid and interface science**164**(1-2): 56-88.
22. Shirazi, M. M. A., et al. (2014). "Production of drinking water from seawater using membrane distillation (MD) alternative: direct contact MD and sweeping gas MD approaches." Desalination and Water Treatment**52**(13-15): 2372-2381.
23. Shirazi, A., et al. (2015). "A review on applications of membrane distillation (MD)

process for wastewater treatment." Journal of Membrane Science and Research**1**(3): 101-112.

24. Tiwari, G. N. (2002). Solar energy: fundamentals, design, modelling and applications, Alpha Science Int'l Ltd.