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RECOVERY AND REUSE OF SPENT CAUSTIC SODA FROM THEMERCERIZING SECTION OF TEXTILE UNIT

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Abstract:

The objective of this research was to see how efficiently caustic soda could be recovered by membrane technology from mercerizing wastewater from a textile manufacturing company. Ultra-Filtration (UF) and Nano-Filtration (NF) procedures were studied for this purpose. In a first step, pretreatment options of occlusion, centrifugation and micro-litigation were evaluated, in an attempt to control for potential membrane contamination. A better option is to use NF for Caustic Recovery. NF has been successfully employed to recover caustics from mercerizing process effluents from both cotton and polyester fabric manufacture in recent research. Despite the high caustic recovery, membrane performance was not assessed in terms of pollutant characteristics like COD or colour removal. Furthermore, in both of these experiments, only one type of NF membrane was tested. Better in high temperature temperatures should also be considered due to the nature of the mercerizing processes. Based on the findings of this research. In general, it can be stated that combining UF and NF treatment to treat caustic processing wastewater results in wastewater that can be recycled in the refining process after evaporation. Pure caustic penetrates through the membrane, but dissolved and suspended compounds are largely intact and concentrated. The caustic is recovered to the rate of 95% or more, while the concentration is constant.

Keywords: Spent caustic recovery, Mercerizing unit, Ultrafiltration, Nanofiltration, Membrane.

Introduction:

After food, cloth has been the second most important need of humans. Producing fibers and then processing them to manufacture clothing are important milestones in the textile business. With population growth and living standards, this need is pushing the textile industry forward. As a result, the textile industry has established itself in close proximity to major export and export markets [16 - 17]. Fabric factories often face shortages of water resources due to shortages and constraints [1,2]. These findings have prompted the attention of other water-saving measures and the discovery of the textile industry [3 - 5], which means that the treatment of contaminated water at the end of the pipeline is effective. In general, membrane techniques are regarded as practical alternatives to the wastewater treatment of textiles for the purpose of recycling them [6]. Various chemicals and additives are used in the manufacture of fabrics to treat fibers to improve process efficiency or to provide specific fiber structures. These compounds make fabric difficult to stain.Alkali, acids, salts, and solvents are the basic chemicals utilized in textile processing [1,7].

Mercerization is a significant finishing technique in cotton textile manufacture that employs caustic (NaOH) as the primary chemical. This method is often used to improve the combination of dye, sheen, and fiber strength. Simultaneous disposal of wastewater and caustic discovery is the most profitable option for disposal of caustic mercerizing wastewater. There are now two types of procedures to recover caustic from mercerizing contaminated water. Planned evaporation is one of them, and it has been in use since 1900. Weak caustic in caustification rinsing solutions can be concentrated to reusable levels with this technology, which employs a multi-staged evaporation process. Caustic soda should be cleaned after straining [8] .However, due to the operational complexity caused by the large range of chemicals used in textile production, this technology is not widely accepted. Because of these problems, a second method, based on membrane filtration procedures, was developed. Membrane filtering applications are considered an effective option for both wastewater use and caustic detection. Among membrane filtration techniques, ultrafiltration (UF) is generally considered appropriate for the extraction of particles and macromolecules from fabric debris [9,10], but not ionic types. Additional treatment using nanofiltration (NF) or RO is needed to separate biological components of low molecular weight and divalent salts, hence for caustic recovery [10,11].

Membrane filtration has found application in many industrial areas for the recycling of extremely alkaline water and caustic discovery. Zhao and Xia [12] found sodium hydroxide in wastewater disposed of following hazardous treatment of shrimp residues in the chitin industry using UF with a stainless steel measuring driver integrated with the NF system. This study showed that UF in combination with NF may also receive NaOH solution (96%).Another study regarding caustic detection from soda solution (CIP) in dairy areas found that microfiltration (MF) performance was as effective as keep surfactants at low cost. However, the COD saturation of MF waste was significantly higher compared to the amounts of UF and NF [13] . In a few recent studies [10,15], NF was employed to recover caustic from mercerizing waste from both cotton and polyester fabric manufacture.

As previously noted, there is currently a lack of research in this area of caustic recovery from mercerizing effluents. In mercerizing wastewaters, colour, suspended particles, COD, and temperature are all quite high. Because mercerizing wastewaters are frequently generated at temperatures ranging from 80 to 90 degrees Celsius, high temperature must be considered as an operational parameter. The feed to the membrane recovery system creates caustic-containing permeates, which are then evaporated. The use of membrane technology in UF is regarded as a caustic recovery approach. Although it has been used to recover caustic from mercerizing process effluents, it is more commonly thought to be suitable for particle and macromolecule removal; nonetheless, decolorization necessitates additional treatment. NF, on the other hand, is useful for decolorization and separation of divalent ions and low molecular weight organic molecules. It has a particular softening effect as well.

As a result, using NF for caustic recovery is a better solution. NF has been effectively used to recover caustic from mercerizing process effluents from manufacturing units in a few recent studies. Despite its excellent caustic recovery, membrane performance was not evaluated in terms of pollutant characteristics like as COD or colour removal.

Materials and Methods:

The flocculation, centrifugation, and MF procedures were used in the pretreatment tests. 500mL glass beakers were used in the flocculation process, along with a standard jar-test apparatus. In these batch experiments, waste water samples from the mercerizing machinery's two rinse tank effluents were combined and placed in jars, where they were mixed slowly at 30rpm for 45 minutes at room temperature $(20^{o}C)$, as shown in Figure 1.

Figure 1. Experimental setup for UF and NF tests

The use of centrifugation as a previous work was reviewed and the results obtained in the flocculation test. The lye from mercerizing sections were collected and mixed at 2500 rpm for 30 minutes. In both cases, there is a significant increase in the stability of the alkaline wastewater.

Experiments with MF were carried out in two stages. A dead-end conventional vacuum filtration machine operating at a vacuum level of 25 in Hg was employed in the first stage. The MF membranes consisting of different pore sizes were taken for the study and the waste water samples are treated at room temperature. A computer-controlled filtration device was employed to filter the identical waste water sample in the second stage of the MF investigations.

At room temperature (182°C), PTFE and PVDF membranes with pore sizes of 5 and 10m were used. PES was discovered to be the best suited membrane material for caustic recovery after further testing. The performance of PES membranes with pore sizes of 5 and 10 m was then tested using the same apparatus and settings. Cross-flow UF and NF tests were performed throughout the caustic recovery investigations.

Table 1. Characteristics of UF and NF Membranes used

Membrane	**Material**	**Operating Temperature(◦C)**	**Max Pressure**	**pH**	**Type**
MF-45	Celluloseacetate	80	1.5	1-11	MF
GR95PP	Polyethersulfone	85	10	1-13	UF
NP010	Polyethersulfone	95	40	0-14	NF
NP030	Polyethersulfone	95	40	0-14	NF
MPT-34	Polyethersulfone	70	35	0-14	NF

Non-pretreated but coarsely filtered wastewater samples were used in UF tests. Prior to UF, wastewater samples were coarsely filtered using a metallic strainer with a pore size of 500 microns. The pore size of the membrane used is 0.01µm, 0.001µm and 0.0005µm respectively form icrofiltration module, Ultrafiltration module , Nanofiltration module respectively. Area of the membrane is 1.8 sq m^2. Both permeate and retentate are recycled back to the feed tank in this mode of operation.

Permeate flow rate was manually measured throughout the tests to determine permeate flux. This procedure was repeated until a constant permeate flux rate was achieved. COD, colour, pH, conductivity, and NaOH content characteristics were also assessed in feed and permeate samples obtained at different time intervals during the membrane operation to evaluate system performance.

Like the UF tests, the wastewater used in the NF testing was only moderately filtered. For this objective, three different types of NF membranes were evaluated on this effluent. The membrane module was used in NF experiments as it was in UF research.

Furthermore, the same operational conditions and performance indicating metrics were maintained throughout. A concentration-mode membrane research was carried out in addition to the UF studies. Similarly, wastewater is heated to 45–80 degrees Celsius and kept constant by a heater in the module's feed tank to see the effect of temperature. Studies in both the concentration mode and at high temperatures have strengthened our understanding of the real-world conditions of caustic recovery. During the NF studies, the best operating conditions and the most effective membrane for caustic recovery were observed.

Nano filtration module, on the other hand. The membrane has a surface area of 1.8 square meters and the outlet liquid from the membrane are recirculated to the storage tank. Permeate flow rate was manually measured throughout the tests to track permeate flux. This method was conducted until the permeate flux rate remained constant. To evaluate system performance, COD, colour, pH, conductivity, and NaOH concentration were measured in feed and permeate samples taken at various time intervals during the membrane operation.

Results and discussion

The mill's mercerization wastewaters were examined before treatment options were considered. The effluents of the mill's two most frequently used mercerization machines were investigated for characterization (Over-Dye and Pad-Steam). To use it, effluents from each of these two machineries' or mercerizing process lines' post-rinsing tanks, as well as combined waste water from these lines (after a coarse filtering unit), were analysed separately. Five separate samples were taken at various intervals and their contents were studied.

Table 4 shows the UF system's successful performance results in terms of caustic colour separation and COD dissolution. Because NaOH is a primary contributor to alkalinity and administration, there is no significant change in pH or conductivity levels.

All of the previous studies suggest that caustic recovery can be achieved using the UF process without any pretreatment other than coarse filtering. When colour and COD retentions are taken into account, however, this procedure is not suitable. These two criteria are assessed in terms of the permeate's reusability in manufacturing operations. The permeate cannot be 1021tilized in the finishing process without further treatment since it is highly coloured and contains a considerable amount of COD-causing organic compounds.

Table 2. Permeate side composition

Parameters	**Feed**	**Microfiltration**	**Ultrafiltration**	**Nanofiltration**
NaOH Content (g/L)	44	34	18	16
P^H	12.76	12.90	12.91	13.01

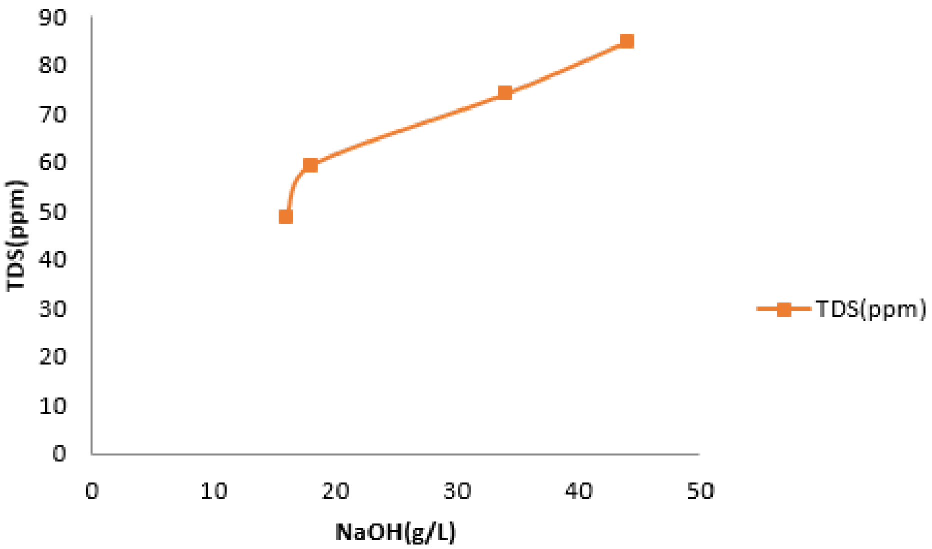
TDS (ppm)	85	74.2	59.3	48.9
Turbidity(NTU)	130.76	114.15	91.23	79.2
Purity (%)	4.42	3.44	1.56	1.56
Conductivity	127692	111080	94150	86780
COD(mg/L)	80	70	80	74

Table 3. Retentate side composition

Parameters	Microfiltration	Ultra filtration	Nano filtration
NaOH Content (g/L)	13	8	1.8
P^H	12.09	12.27	12.31
Conductivity	43725	37135	31500
TDS (ppm)	63.75	57.6	51.3
Turbidity(NTU)	38.2	29.2	13.2
Purity (%)	2.37	3.23	3.56

Variation of NaOH content with TDS

The NaOH Content coming from each stage of the membrane module of the permeate side is decreasing whereas the TDS also decreases and the same trend were observed for retentate.



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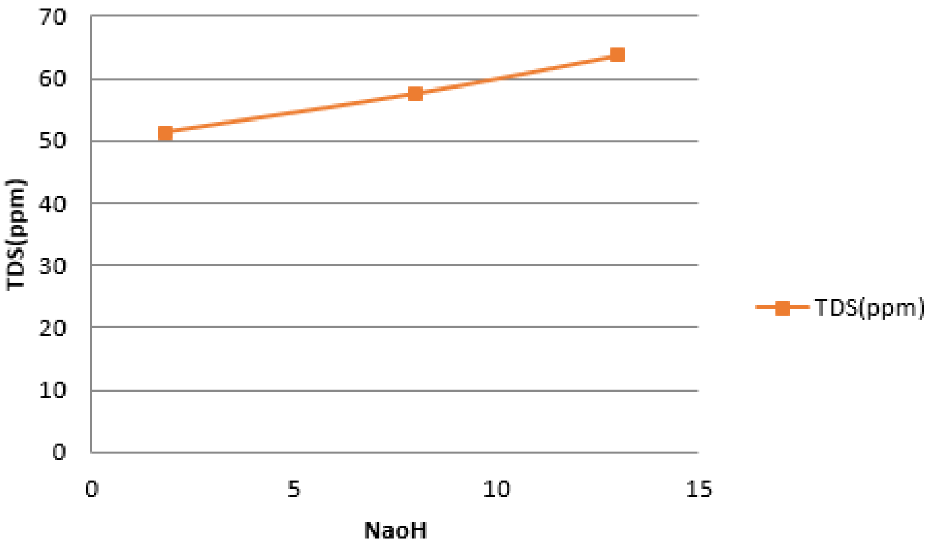
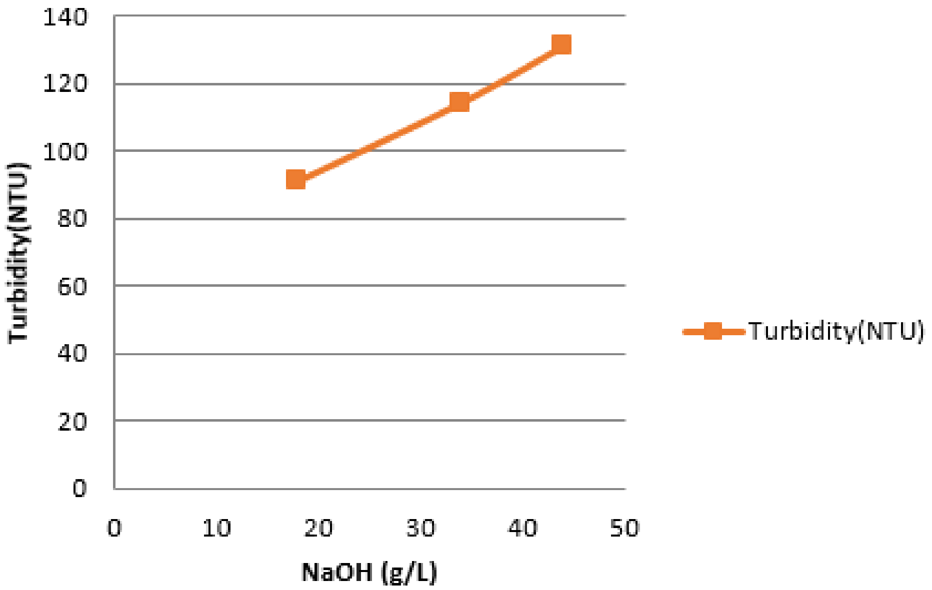


(b)

Figure 2. Variation of NaOH content with TDS (a) Permeate side and (b) Retentate side

Variation of NaOH content with Turbidity

In each stage of filtration section the turbidity of the solution keeps on decreasing with the decrease in NaOH Content. The Turbidity of the filtrate from each section decreases in the retentate side also.



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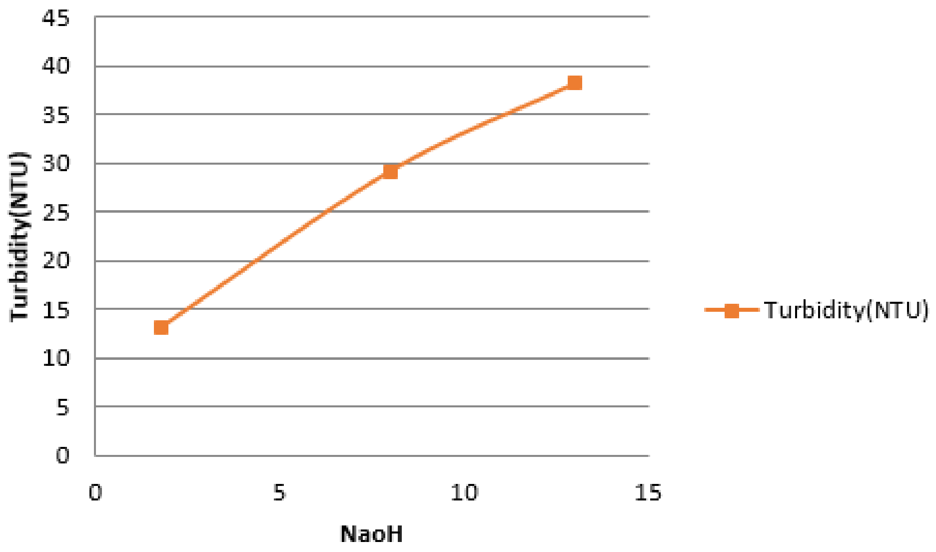

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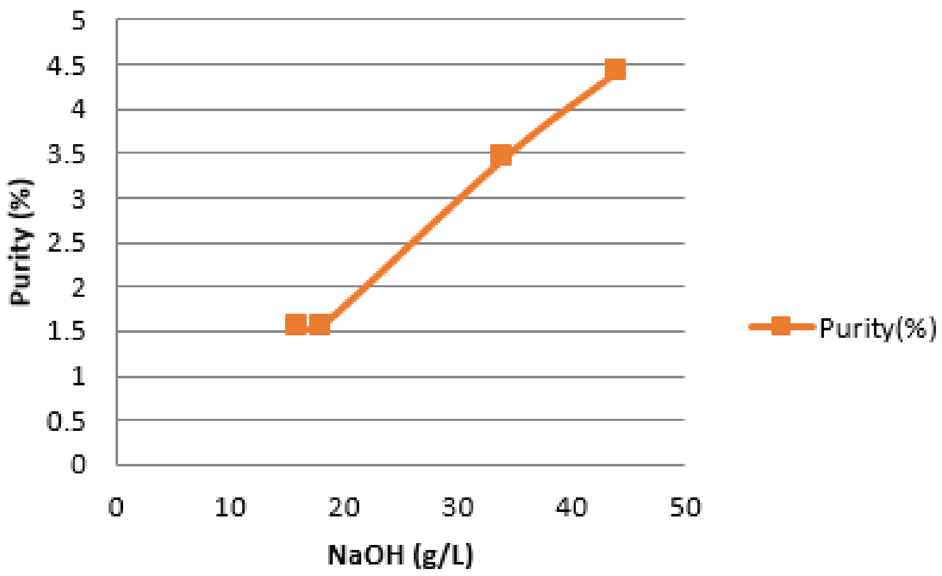
Figure 3. Variation of NaOH content with Turbidity, (a) Permeate side and (b) Retentate side

Variation of NaOH content with purity

The Filtrate coming from each membrane module at room temperature has decreasing trend of purity. The purity of the sample in the retentate side increases in each module



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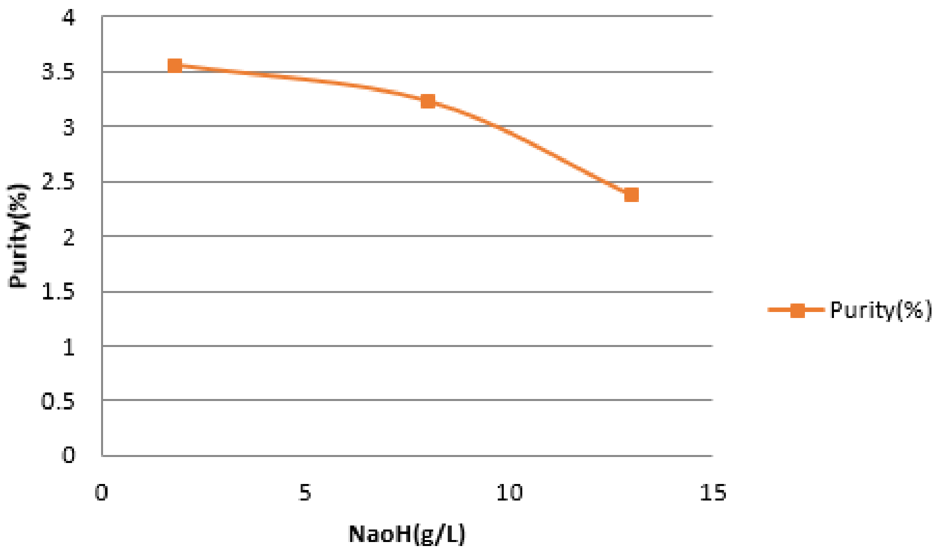
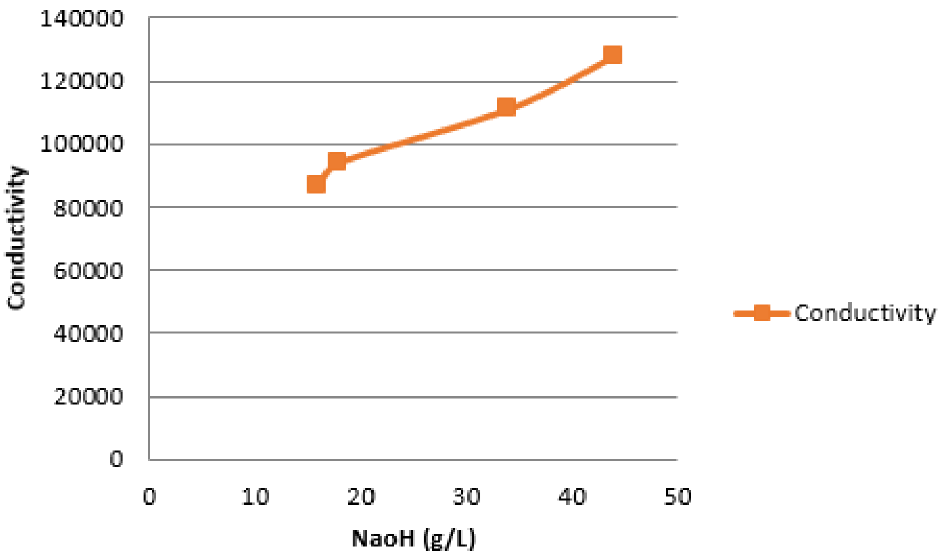


(b)

Figure 4. Variation of NaOH content with purity, (a) Permeate side and (b) Retentate side

Variation of NaOH content with conductivity

With the decrease in TDS of the filtrate in each membrane module the conductivity of the sample increases. The left out NaOH content in the permeate side is found in the retentate side where the same trend as in the permeate side is exhibited.



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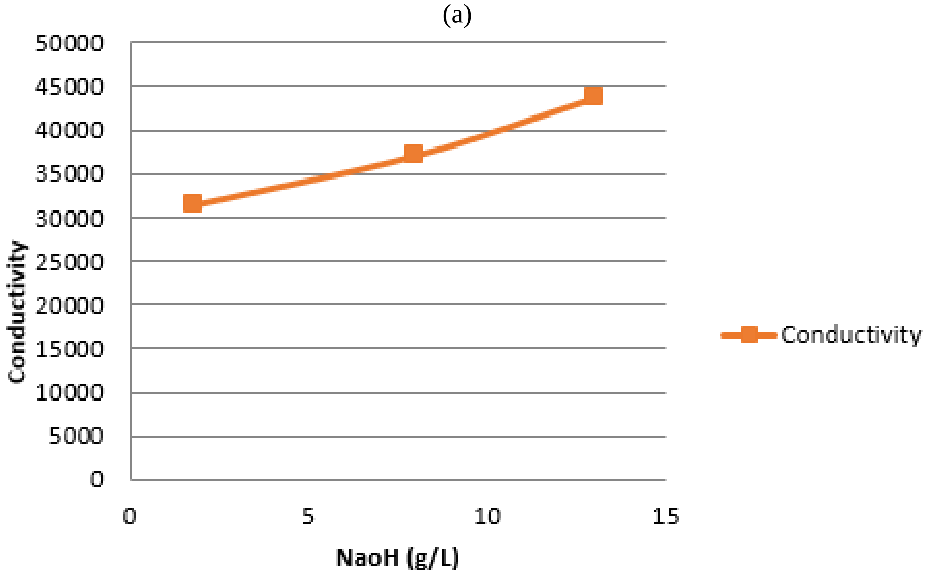

Figure 5. Variation of NaOH content with conductivity, (a) Permeate side and (b) Retentate side

Variation of COD with change in Caustic concentration

The Chemical Oxygen Demand of the filtrate sample from each section decreases in each module which shows that there is less organic growth.

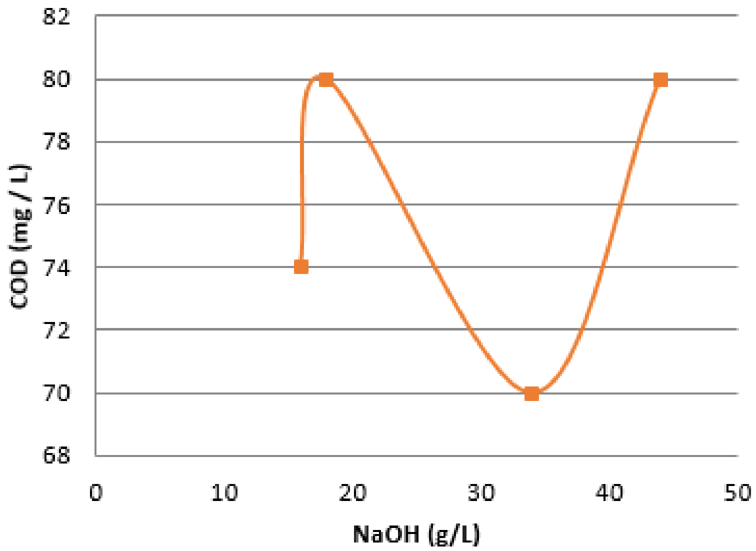

Figure 6. Variation of COD with change in Caustic concentration

Permeate flux variation with time

At constant temperature and pressure flow flux at each stage of filtration is checked and is found to have a decreasing trend of flow flux at different time intervals due to clogging of the membrane pores.

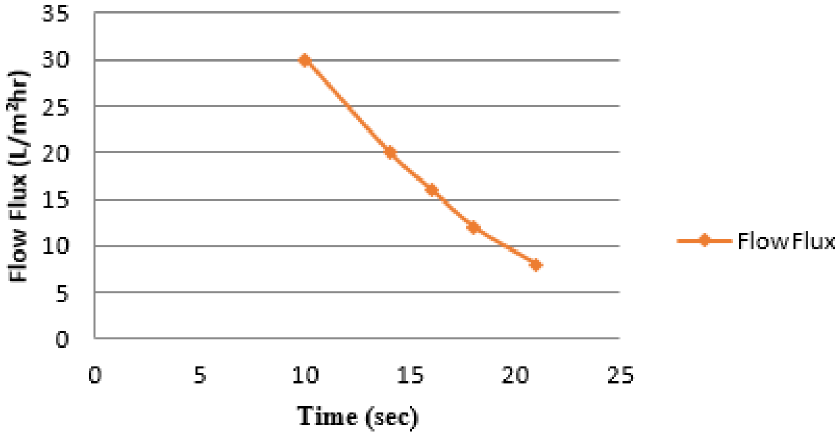

Figure 7. Permeate flux variation with time

Caustic recovery with varying temperature

When the temperature of the feed is increased there is no change in flow flux with time is same as that at room temperature and pressure. But the NaOH content at permeate side increases with increase in temperature.

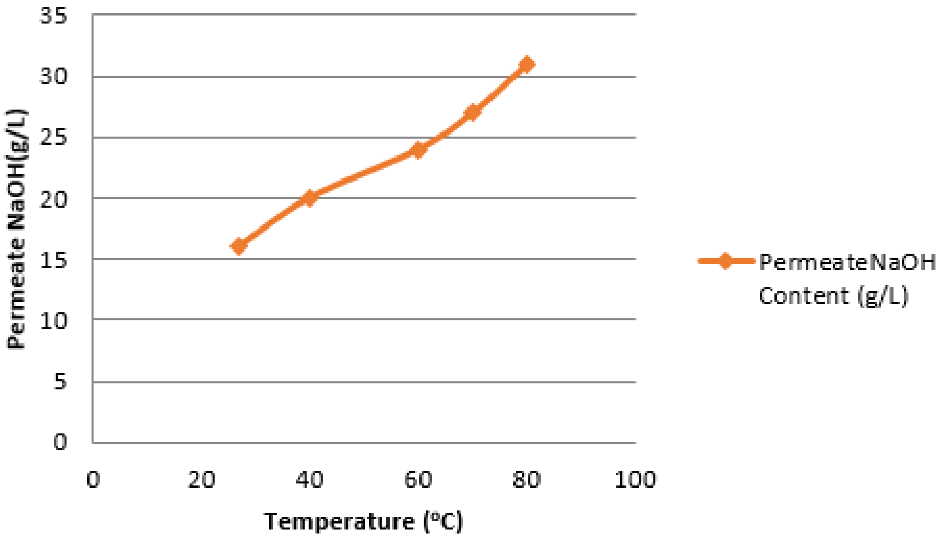

Figure 8. Caustic recovery with varying temperature

Conclusion

Based on the findings of this study, it can be argued that combining UF and NF treatments to treat wastewater depletion results in the quality of disposable disposal restored to the disposal system after evaporation. While the purified caustic travels through the membrane, the dissolved and suspended material is virtually totally retained and concentrated. The causticis recovered up to 95% of its original volume, although its concentration remained unaltered.

- The following are some of the other findings of this research:
- Results of previous laboratory treatment experiments have shown that MF, flocculation, and centrifugation do not work and do not work in advance treatment procedures to eliminate contaminated water from the production of denim fabrics.
- Laboratory experiments with the UF membrane have showed that it is capable of producing a relatively clean caustic solution with colour retention of 93.86 percent and COD retention of 83.84 percent. Because the permeate's colour and COD (2590 mg/L) are still high, it suggests that more purification is required.
- FurtherpurificationofthepermeatefromUFviaNFmembraneswassatisfactoryprovidingaclean permeate or caustic solution.
- NF membranes performed better in terms of permeate flux and colour and COD removal, with 94.9 percent and 85.06 percent, respectively.
- From the graph it is noticed that at room temperature and pressure the NaOH Content from each membrane module decreases whereas TDS, Conductivity, turbidity and permeate flux decreases.
- At varying temperature it has been noticed that the NaOH content from each membrane module has increased to an approximate level.

Nomenclature

BOD	-Biochemical Oxygen Demand
CFV	-Cross Flow Velocity
COD	-Chemical Oxygen Demand
MF	-Microfiltration
MWCO	-Molecular weight cut-off
NF	-Nano-filtration
PES	-Poly ether sulfone
PTFE	-Poly tetrafluoro ethylene
PVA	-Polyvinyl alcohol
PVDF	-Poly vinylidenefluoride
RO	-Reverse Osmosis
TDS	-Total Dissolved Solids
TMP	-Trans Membrane pressure
TSS	-Total Suspended Solids
UF	-Ultrafiltration

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