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An SPSS and CNN modelling based quality assessment using ceramic materials and membrane filtration techniques

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ABSTRACT

This study investigates the treatment of Sago Wastewater (SW) using natural materials and α-Al2O3 ceramic membranes for filtration. SW samples were collected from influent and effluent of sago industries in Salem and Namakkal districts, Tamil Nadu, as well as from nearby open wells and bore wells. The physico-chemical parameters, including pH, color, turbidity, TSS, TDS, TS, DO, COD, and BOD, were analyzed. High levels of BOD (1800–1550 mg/L) and COD (3400–4150 mg/L) were observed, reflecting the high organic content of the effluents. Post-filtration, pH values ranged from 6.9 to 7.3, with BOD and COD levels within permissible limits set by TNPCB. Toxic substances were reduced by 52% to 96%. Statistical analysis using multiple linear regression showed an R^2 of 0.98 in the predicted phase and 0.9 in the treatment phase, while CNN analysis yielded an R^2 of 0.99 with an MSE of 5.9 after 2000 epochs. The filtration process significantly reduces toxins, making the treated water suitable for irrigation purposes.

Keywords: Sago industry; Ceramic membrane; Physico-chemical parameters; Convolutional neural network.

1. INTRODUCTION

India's population is particularly vulnerable to changes in the water supply and wastewater problems. Nearly two-thirds of India's agricultural land is rain-fed, and over 60% of the country's population makes their livelihood from agriculture. India is therefore considerably more vulnerable as a result of the monsoon's impact from climate change, which has had and will continue to have a major impact on agriculture. The government has also started ambitious schemes like the "Make in India" campaign and the "Smart City Mission," which should be examined from water and environmental perspective [1–5]. Have described the sago factory effluent and reuse the water for industrial uses. A treatment facility based on microbial systems was developed as the goal of this study. SAVITHA *et al.* [6] has analyzed the physico-chemical properties of sago processing wastewater from various sago enterprises using the upflow anaerobic filter zone of the anaerobic hybrid reactor (AHR). The pH TSS, COD, and BOD ranges were analyzed [7].

Have described the goal of this study as to develop a ceramic water filter that can remove heavy metals from water at the home level. In this work the ceramic water filter composition can be used for removing heavy metals form wastewater. SHANKAR *et al*. [8] discussed numerous ways that wastewater may be treated using nano filtration. There was discussion and presentation of the performance of nano filtration membranes, including operating settings, feed characteristics, and membrane features [9]. The process of oxidation and ultrafiltration for synthetic sago wastewater and real sago wastewater treatment. The system successfully removed the contaminants from both the synthetic and actual sample of sago water. The removal efficiencies for COD were 85% and 90% [10]. Presented the results of this study and have showed that used wood filter. GAC was not included in any of the filter systems that contained the native wood species Combretum erythrophyllum in System [11].

Investigated tainted water and bore water collected from three different locations and subjected to physical and organic treatment. This investigation aims to investigate the effectiveness of the treatment for sago water reuse using three models that use fine aggregates, varying sizes of coarse aggregate, powdered activated carbon in account of quicksand channel design and complexity, and bore water standards [12]. Membrane-based techniques for treating industrial wastewater in order to manage the environment and reuse

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water. The applications for treating waste from various industries, pressure-driven membrane operations hybrid systems are examined [13]. Membrane technology for wastewater treatment like the oily water treated by MF removes 90.2% of organic additives. The membranes for municipal and industrial wastewater streams have a Molecular Weight Cut-off (MWCO) that are resistant to fouling that is irreversible and have high dye rejection rates. Additionally discussed were various membrane technologies, their merits, drawbacks, and prospective solutions [14].

The ceramic membrane filtration technique was presented. The membrane fouling, filtration behavior and treatment process was presented [15]. Using a ceramic ∞-Al2O3 membrane, cross-flow microfiltration (MF) procedures were investigated with oily wastewater. The findings also showed that low pH levels in the feed solution or high concentrations of salt both caused a decrease in permeate flux. At pH 5.8, the largest continuous flux was 45% higher than at pH 3.8 [16]. Assessed the physicochemical characteristics of textile industries in Salem, Tamil Nadu, India. The groundwater quality was analyzed and found that water quality decreased with increasing industrialization [17]. Groundwater samples have been collected from various locations of the study area of Salem and the Physico-chemical parameters have been analyzed and the results are compared with the WHO and ICMR drinking water standards [18]. Research has been done on the effects of dyeing effluents, agricultural runoff, and municipal sewage on the quality of the water. Salem is a slowly but steadily expanding city that is significant due to its educational institutions, textile industry, steel plant, manga industries, and magnesium industry. Determining the physical and chemical characteristics of ground water is the focus of this study. Because of its topography, groundwater was always determined to be hard [19, 20]. The physico-chemical properties of wastewater from sago processing (SWW) from several sago factories in Tamil Nadu's Salem and Namakkal districts were investigated [21–23]. According to the findings, the effluents from this area are primarily supra-colloidal and have a whitish to greyish brown tint [24–28].

In the above literature, many researchers was explained the various technique of wastewater treatment. In this paper demonstrated the filter technique with locally available waste materials used as a filter media like Gravel and Pebbles, Rice husk ash, Charcoal, Coconut coir and Fine Sand. The sago wastewater samples were collected from three different sago industries and various sample (openwell and borewell water) were collected from around the sago industries. In this investigation on ceramic membrane α-Al_2O_3 was utilized for treating the wastewater. From the treated water was suggested for the agricultural usage. Additionally, the SEM analysis was conducted for the filtering layers and membranes which provide the clear visibility of contaminants. Apart from this, the treated samples were analysed in SPSS software and on another hand CNN analysis was employed for finding the relationship between the model and parameters of wastewater.

2. MATERIALS AND METHODS

2.1. Materials

The present research focuses on sago wastewater purification by the natural materials are pebbles and gravel, fine sand, coconut coir, charcoal, rice husk ash and α-Al_2O_3 ceramic membrane, which was used in the present filtration model. The proposed filtration model was introduced for the filtration of wastewater. The pebbles are greater than granules (2 mm to 4 mm in diameter) and lesser than cobbles (64 mm to 256 mm in diameter). The different sizes of pebbles are used in this investigation. The size of the fine sand lies between 0.074 mm and 4.75 mm. The colour of the charcoal is black and it is a very lightweight material and easily breakable. When the combustion of husk, the lignin, and cellulose are removed, the pozzolanic ash is obtained with a grey colour. This pozzolanic ash is used for treating the wastewater. The coconut coir is made up of small threads, each less than 0.05 inch (1.3 mm) long and 10 to 20 micrometers in diameter. The thickness of the membranes used in the wastewater proposed treatment is 5.5 mm. The membranes have an asymmetrical structure with a porous size of the microfiltration membrane 0.02 µm. The ceramic membrane runs at a Crossflow filtration. The PCFM-A-20-3-U ceramic membrane purchased from Qingdao Jinhuimo International Co.Ltd. Quingdao, Hong Kong.

2.2. Study area and sample collection

Sago industries' wastewater, openwell and borewell samples were collected in the mentioned sago industries. Figure 1a represent the collection of waste samples from the various sago industry places. The Salem and Namakkal sago cluster areas served as the study's locations. The intensity with which small-scale manufacturers produce sago and the sites where wastewater is disposed of directly into the environment are the basis for site selection. The sago wastewater was collected in the inlet and outlet from different sago industries located at the Salem and Namakkal Districts of Tamil Nadu, India. The collected wastewaters were immediately stored to avoid inconsistency in its physicochemical properties [7].

The openwell and borewell water samples were collected in and around the sago industry for a distance of 0 to 5 km radius. The openwell locations were identified with respect to distance and Azimuth (angle) using a Global Positioning System (GPS). Using the survey results, the openwell and borewell water locations were fixed over 0-5 km radius in all directions in and around the industry as indicated in Figure 3. The number of samples in each area was fixed with respect to the area covered under sago water irrigation. The study area is divided into 4 areas. The Physico-Chemical parameters of the filtered samples, such as BOD, COD, DO, pH, Turbidity, TSS, TS, TDS, Calcium, Sodium, Potassium, Chloride, etc., are determined by laboratory tests.

2.3. Experimental setup and operation

The proposed Model consists of a gravels and pebbles layer as the first layer. Then the rice husk ash layer is used as the second layer. Then, the charcoal layer is furnished as the third layer. The fine sand is given as the final layer. Each filter contains coconut coir at the bottom side. The α-Al_2O_3 ceramic membrane was used as the last step of the setup to filter the water from micro waste products. The proposed vertical filtration Model is shown in the below Figure 2.

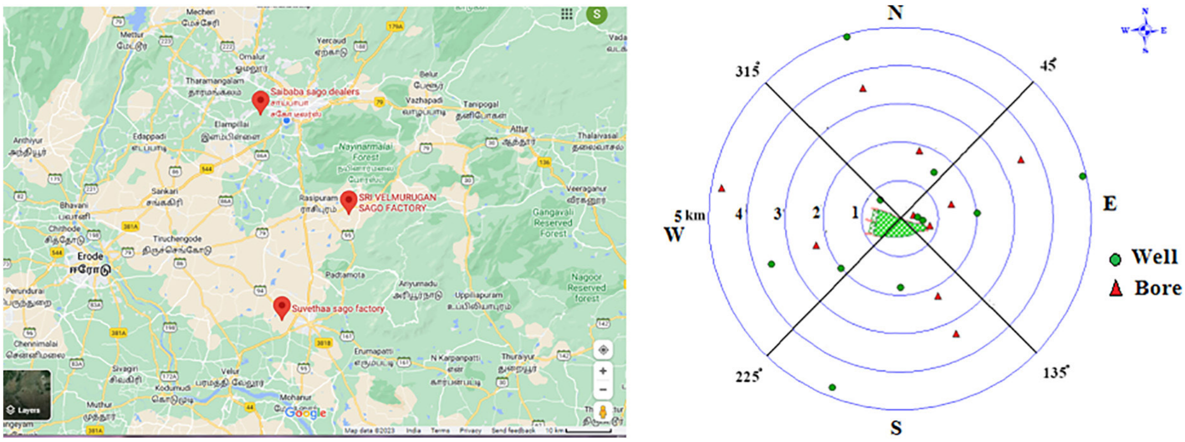

Figure 1: Sample collections in three industries.

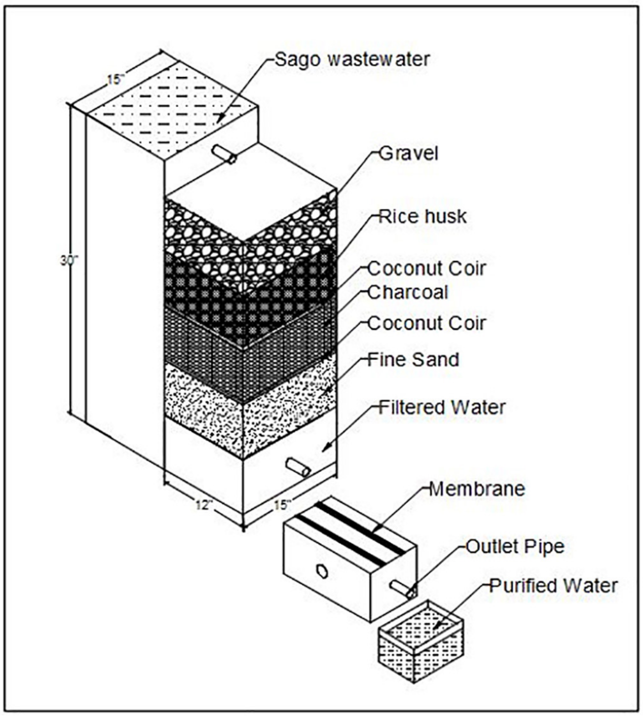

Figure 2: Vertical filtration model.

2.3.1. Flowrate observation

Flux rate calculation

$$\text{Flux rate } \frac{Q}{AT} \text{ (L/m}^2\text{h)} \tag{1}$$

Here, Q = Volume of flow (L), A = Area of the membrane (m^2), T = Time (hour)

Example calculation for the flow rate, Q = 9.7 liter, Area of the membrane = 0.145 × 0.04, A = 0.0058 m^2 T = 4 hours

$$\text{Flux rate} = \frac{9.7}{0.0058x^2} \tag{2}$$

$$= 836.20 \text{ L/m}^2\text{h}$$

In Figure 3 X axis shows the operation time in min and Y axis shows the Flux in L/m^2.h. At 30 minutes of operation time the corresponding permeate flux was 836.2069 L/m^2·hr and increased to 1672.414 L/m^2.hr after 60 minutes. At 120 min of operation time, water flux increased to 3344.828 L/m^2·hr. The flux rate was gradually raised 6689.655 L/m^2·hr for 240 minutes.

2.4. Data analysis

2.4.1. Multiple regression analysis

The link between one dependent variable and several independent variables may be analyzed using this statical technique. Using an independent variable with known values to predict the value of a single dependent variable is the primary objective of multiple regression analysis. In the data and variable views, the ten samples (the above-limited samples) and acceptable limits were taken.

$$Y_{BOS} = x_1COD + x_2N + x_3P + x_4K + x_5TH \tag{3}$$

where, YBOD: BOD values, X1, X2, X3, X4 and X5: constant coefficients of linear regression model, COD, N-Nitrogen, P-Phosphorus, K-Pottasium and TH– Total Hardens are input parameters. The quality of the fit polynomial model was stated by the coefficient of determination (R2), adjusted R2, and its statistical significance was determined by F test. The effect of variable and the effect of the interaction also were determined, and numerical optimization was performed to determine the optimal solution (maximum BOD removal).

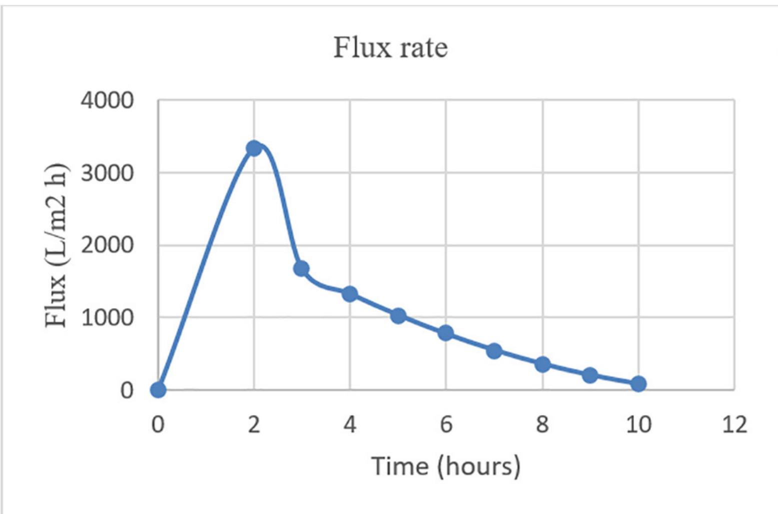

Figure 3: Water flux with respect to time.

$$BOD\ Removal\ (Predicted) = -13.976\ (Constant\ Coefficient) + 0.255(COD) - 0.45(N) - 4.055(P) - 0.119\ (K) + 0.074(TH) \quad (4)$$

$$BOD\ Removal\ (Observed) = -13.956\ (Constant\ Coefficient) + 0.101(COD) - 0.116(N) - 41.521(P) - 0.29\ (K) + 0.107(TH) \quad (5)$$

2.4.2. Convolutional neural network (CNN)

On the other hand, the CNN (Convolutional Neural Network) was used for determining the performance of the purified samples. The suggested treatment procedure used low-cost components and was effective in removing pollutants from the sago wastewater. The overall result obtained from this investigation indicated that the proposed filtration method could be used for Agriculture, BOD removal from sago wastewater treatment as well.

All of the modeling programs used in this investigation were written in Python. Training, testing, and validation are the three modeling stages that typically comprise CNN implementation. The weights linking the neurons are changed using the training group of data. The created model's optimality and generalization abilities are assessed using the test group of data. In contrast, the validation group of data is used to assess the model parameters and network geometry. It is crucial to understand that the model generation procedure did not incorporate the validation set. MSE and R, or "correlation coefficient," values were employed and monitored as performance and monitoring metrics during the training phase.

The removal efficiency of BOD in wastewater is predicted using a CNN-based model in a range of primary and biological treatment systems. In order to do this, models with various CNN topologies were produced by varying the number of neurons in the hidden layer. The performance of the developed CNN models was evaluated for training and independent validation using the correlation coefficient and MSE. Additionally, by controlling the BOD removal effectiveness, the developed CNN models may restrict the amount of high-quality treated wastewater that is released into receiving water.

A CNN topology with three primary network layers is seen in Figure 4. After receiving the input data, the first layer—known as the input layer—transmits it to the hidden levels. The neural network's hidden layers, which are made up of many neurons, comprise its core. There may be several hidden layers with a large number of neurons in a single network. The complexity of the system to be modeled often corresponds to the number of hidden layers (Dreyfus 2002). For the various network types, CNN's operating premise is essentially the same. After receiving input signals and processing them through an activation function, the neuron—the fundamental processing element—produces an output signal. Additionally, the transfer functions and each neuron's weight are in charge of transmitting impulses from one layer to the next.

3. RESULT AND DISCUSSION

3.1. Experimental results-before filtration

The Sago industry wastewater makes an impact on the soil and ground water. Additionally, sago outlet without a properly treated wastewater has constituted potent toxicant to the soil, soil organisms, water and plants. The

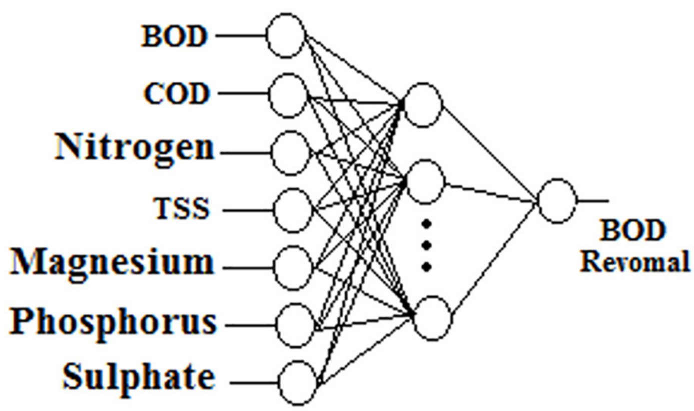

Figure 4: Typical structure of a CNN.

sago wastewater, openwell water and borewell water were collected in the specified location as mentioned in Figure 1. The samples were collected in the suitable containers with a quantity of 1000 ml.

The Turbidity of the given wastewater varied from 58 to 52 NTU, which was found by the turbid meter as per IS 3025 (PART 10). Total suspended solids differed between 1215 mg/l to 550 mg/l determined by the gravimetric method as per IS 3025 (PART 17). Total dissolved solids of samples varied from 1450 mg/l and 1850 mg/l obtained by the gravimetric method as per IS 3025 (PART 16). Total solids of samples obtained by the addition of total suspended solids, and dissolved solids varied between 2812 to 895 mg/l. Based on IS 3025 (PART 21), the total hardness (as CaCO3) of each sample varied between 620 to 160 mg/l obtained by the Ethylene Diamine Tetra Acetiacid (EDTA) method. The changes in COD of wastewater samples between 4950 to 45 mg/l were examined based on the IS 3025 (PART 58). The BOD content of the ranges started at 2.4 mg/l and ended at 7 mg/l obtained at 27°C with 3 days of incubation with the help of IS 3025 (PART 44) (1993). The DO in the wastewater samples lied between 8.3 mg/l and 6.5 mg/l, and determined by the titrimetric and electrometric method as per IS 3025 (PART 38).

The before filtrations of physico-chemical characteristics for different sago industries (as named "A", "B" and "C" were mentioned in Table 1), openwell and borewell water are presented in Table 2. The sago wastewater, openwell and borewell water samples were collected towards East, West, North and South directions around the sago industry by considering the industry as nucleus at a distance of 0–2.5 km, and 2.2–5 km. Sample 1 is the plant influent, sample 2 is the filtered plant effluent water, East directions 1 openwell and 1 borewell samples 3 and 4 were taken respectively. Sample 5 and 6 are taken West directions 1 openwell and 1 borewell. Same procedure are followed by the North and South directions for the sample 7 to 10.

The physico-chemical parameters are found in some places the openwell water and borewell water within the permissible limit in the location of 2.5–5 km samples. The samples which exceed the described limit and the above limit samples are taken for the wastewater treatment by using the proposed filtration model.

3.2. Experimental results-after filtration

After the filtration, the acceptable pH range comes from all three sago factories, well and borewell water. The effectively reduced the pH content is 6.35 to 7. The proposed Model reduced the pH value of 16.1% in "A", 17.5% in "B" and 17.65% in "C" respectively. The values indicate that there is no impact of effluent on groundwater quality in the nearby areas of the industry. The color and Odour of the Sago wastewater effluent is in dark brown in colour with pungent smell due to partial decomposition of starch and it very often exceeds the permissible limit. This is primarily due to the dissolved substances and some degraded products. The pH analysis is presented in Figure 5(a).

The proposed model is the most effective in removing the turbidity of the three sago wastewaters. After the filtration the turbidity in "A" industry is 0.9, 0.28, 0.15, 0.21, 0.1 (sample 5 to 8), 0.05 and 0.1 in mg/l. The Turbidity analysis is shown in Figure 5b. At industry B the values are 0.8, 0.22, 0.2, 0.25, 0.2, 0.15, 0.2, 0.1 and 0.05 in mg/litre, At industry C the values are 0.75, 0.2, 0.3, 0.2, 0.1 (sample 5 to 8), 0.2 and 0.1. The proposed model reduces the turbidity to 65% in "A", 67.5% in "B" and 67.65% in "C" respectively. The Figure 6a and 6b shows the different industries analysis of TSS and TDS respectively. TSS of the receiving waters varied between 28-35 mg/l in "A", "B" and "C" industry wastewaters. After the treatment TSS were reduced in the proposed model by 65.28% in "A", 69.26% in "B" and 69.68% in "C" respectively. The minimum and maximum TDS values in the proposed model are 566 mg/l and 1400 mg/l. The proposed model removes the TDS in 34.02% in "A", 33% in "B" and 32% in "C" respectively.

Table 1: Sago wastewater collection sites.

GOOGLE MAP CODE	NAME OF INDUSTRY	GEOGRAPHICAL COORDINATES OF SAMPLING SITE		REGION DETAILS
		LATITUDE	LONGITUDE	
A	Savethaa Sago Factory	11.3169°N	78.14°E	Nammakkal, Tamil Nadu-637019
B	Baba Sago Factory	11.65°N	78.059°E	Sivathapuram, Salem-636307
C	Velmurugan Sago Factory	11.46°N	78.24°E	Sendamangalam, Rasipuram-637406

Table 2: Physico-chemical characteristics - Sago industry (before treatment).

S.NO	PARAMETERS	SAMPLE 1			SAMPLE 2			SAMPLE 3			SAMPLE 4			SAMPLE 5		
		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1	pH	4.46	3.86	4.1	8.52	8.81	8.42	8.1	7.41	7.31	8.6	7.8	7.6	7.8	7.35	6.93
2	Colour	DW	DW	DW	B	DB	DB	CL	CL	CL	CL	CL	CL	CL	CL	CL
3	Turbidity (NTU)	505	525	585	59	58	52	0.8	0.6	0.5	0.5	0.45	0.4	0.3	0.3	0.3
4	TSS (mg/l)	758	865	1420	560	610	1207	27	38	27	21	27	24	22	25	22
5	TDS (mg/l)	1580	2094	1742	1350	1841	1450	1120	2101	1745	1012	1038	1140	1100	1320	1021
6	TS (mg/l)	2338	2959	3162	2812	2451	2657	1147	2139	1772	1033	1065	1164	1122	1345	1043
7	TH (mg/l)	1125	725	1452	620	674	691	180	186	190	170	178	178	175	180	178
8	Phosphorus (mg/l)	14	32.4	19.4	4.2	6.5	11.2	0.0264	0.014	0.019	0.0202	0.01	0.018	0.02	0.0187	0.018
9	Nitrogen (mg/l)	62.5	58.2	62.7	12	19.4	15.4	2.6	2.4	1.91	2	1.8	1.76	2.2	2.0	1.9
10	Potassium (mg/l)	396.4	335.4	356	134	101	203	26	28	21	19	17	14	15	12	11
11	COD (mg/l)	5200	4890	5250	4950	3710	4150	62.5	71.5	72.2	40	60	51.9	67.88	48.18	68.18
12	BOD (mg/l)	2620	2560	3200	1570	1550	1180	4.12	4.2	4.52	2.7	2.78	2.8	3.4	3.61	4.91
13	DO (mg/l)	0.07	0.075	0.077	8.35	9.92	9.4	7.6	8.6	8.1	6.9	7.5	7.0	7.2	7.42	7.5
S.NO	PARAMETERS	SAMPLE 6			SAMPLE 7			SAMPLE 8			SAMPLE 9			SAMPLE 10		
		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1	pH	7.65	7.75	7.9	7.92	7.62	6.87	7.62	7.92	7.82	7.9	7.7	6.9	7.6	7.69	**7.7**
2	Colour	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL
3	Turbidity (NTU)	0.2	0.2	0.2	0.2	0.3	0.15	0.1	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.2
4	TSS (mg/l)	21	24	21	26	21	24	21	22	20	26	24	20	22	20	19
5	TDS (mg/l)	950	1041	887	1019	1210	1200	845	945	974	1041	1124	1147	920	890	864
6	TS (mg/l)	971	1065	903	1045	1231	1224	866	967	994	1067	1148	1167	942	910	883
7	TH (mg/l)	162	172	160	170	174	174	160	164	162	182	180	180	168	172	160
8	Phosphorus (mg/l)	0.0194	0.0164	0.024	0.0193	0.0181	0.024	0.0184	0.0167	0.02	0.019	0.019	0.02	0.0181	0.017	0.02
9	Nitrogen (mg/l)	1.8	1.74	0.98	2.1	1.95	1.8	1.6	1.64	0.84	2.2	1.84	1.79	1.8	1.59	1.6
10	Potassium (mg/l)	11	10	10	18	8	18	10	10	11	16	10	24	11	11	14
11	COD (mg/l)	46.25	66.75	46.75	67.2	48.2	68.4	46.1	66.51	46.12	66.8	48.28	68.3	45.7	64.1	46.5
12	BOD (mg/l)	2.5	2.3	2.8	3.7	3.86	4.9	2.2	2.2	2.65	4.3	3.51	4.6	2.5	2.1	2.7
13	DO (mg/l)	7.0	7.9	7.9	7.3	7.6	7.8	7.6	7.8	7.28	7.2	7.5	7.15	6.9	7.6	7.6

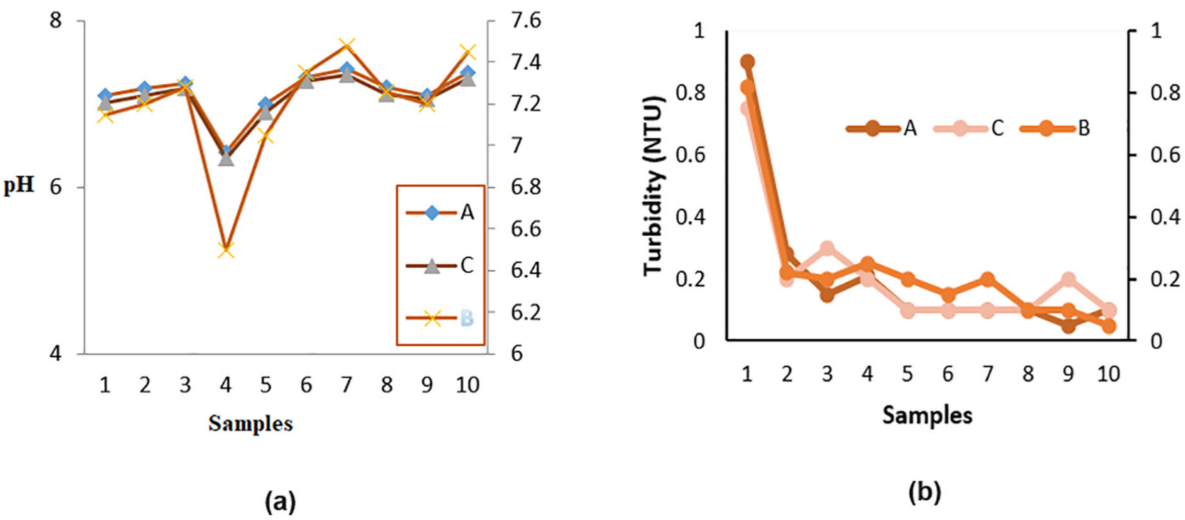

Figure 5: Analysis of (a) pH and (b) Turbidity measurements of the samples ("A, B, C" industry).

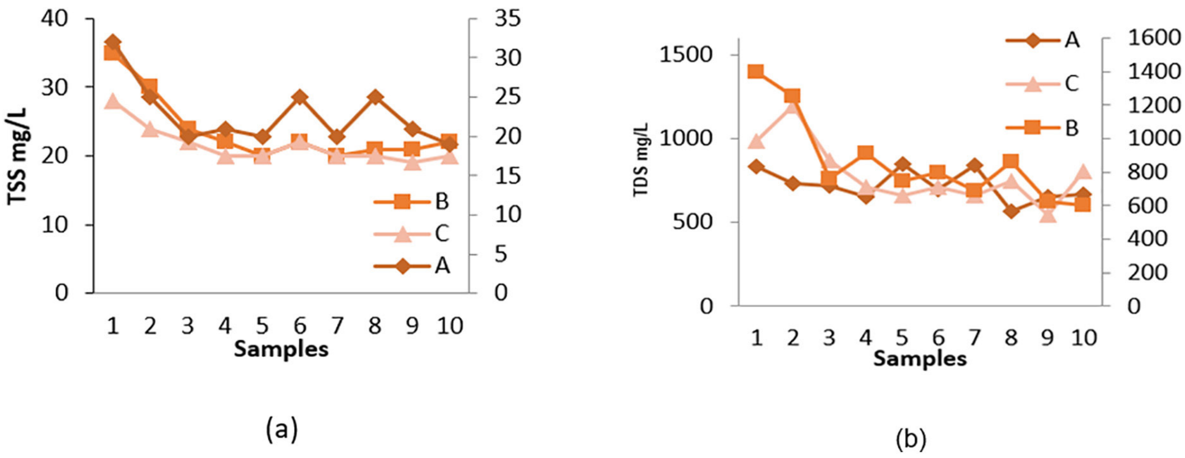

Figure 6: Analysis of (a) TSS (b) TDS measurements of the samples ("A, B, C" industry).

The common range of the TS for all types of Sago was 2812 to 2657mg/l. After filtration by the proposed model the TS value with in the range and it is clearly shown in Figures 6a. TS in the range of 58.8% in "A", 60% in "B" and 63% in "C" sago industries respectively. Because of the presence of coal in the higher layer. Figure 6b show the DO analysis. It was absorbed from the figure that the DO limits are within the standard level in sample 2 to 10 in "A", "B" and "C" sago industries and the proposed model reduces the DO 64% in "A", 65% in "B" and 63% in "C" respectively. Figure 7 shows the Analysis of (a) TS (b) DO measurements of the samples ("A, B, C" industry).

All the three types of sago industry wastewaters relatively varied. The BOD of the waters from all types of Sago industries has ranged widely from as low as 2.1 mg/l to a high of 31 mg/l as presented in Figures 8a. Initial BOD of the sago effluent was found to be above the permissible limit and as the treatment proceeded there was a decrease in the value and after treatment the value was found to be 28 mg/l in "A", 27 mg/L in "B" and 31 mg/l in "C" sago industry respectively. The COD has followed the trend similar to that of BOD, and in all the three types of Sago industries, well and borewell waters, COD of the waters is relatively very low. The average removal rate is roughly 67%. The COD has ranged widely from as low as 32 mg/l to a high of 98 mg/l as presented in Figure 8b. The sedimentation and filtering of particle forms are responsible for eliminating COD.

COD in sago effluent and after treatment the value was found to be 98 mg/l, 86 mg/l and 97 mg/l and the percentage reduction in the COD was found to be 67.02%, 67.68% and 67.66%. A range of 300 to 110 mg/l of total hardness was observed in the location of 0–2.5 km surroundings in "A" industry, 250 to 104 mg/l of TH was noted in "B" industry area of 2.5–5 km and near "C" industry shows the range of 240 to 100 mg/L.

The proposed model is efficient and eliminates as much as 67.6% in "A" industry, 64.2% in "B" industry and 65.5% in "C" industry of the phosphorus content and gives an effluent with phosphorus content of less than 0.1mg/l. The removal percent of N is 65% in "A" industry, 60% in "B" industry and 65.8% in "C" industry. The minimum and maximum potassium values in "A" are 24 mg/land 9 mg/l, in "B" are 25 mg/l and 7 mg/l, and in "C" are 20 mg/l and 6 mg/l respectively. The proposed model reduced the percent of 60.5% in "A" industry, 62.1% in "B" industry and 63.3% in "C" industry. The TH analysis is presented in Figure 9 for A, B and C industries.

3.3. SEM analysis

The membranes were coated 10 nm by using gold sputter coater which is manufactured by Quorum for the SEM imaging. When the operating voltage is 10 kV, the cross-sectional images of the three membranes are found. The pore size distribution is generated by the reconstructed pore spaces from the Scanning Electron Microscopy. Figure 10a,b explains about the α-Al2O3 support layer. This layer consist of a narrow porous surface. As can be seen from the SEM photos, the ceramic membranes have a rough surface with several irregular holes. The membrane's average pore size is 0.02 µm. The pore size is between 0.02 and 0.08 µm, which is consistent with commercial microfiltration membranes for wastewater treatment. Under a scanning electron microscope, the membrane's surface with the pollution reaching the limit displayed a comparatively smooth pollution layer, with sporadic contaminated particles and blocked and covered membrane pores by pollutants, as seen in Figure 10b, c and d. Compared to the membrane before filtering, the quantity and form of membrane holes were significantly different.

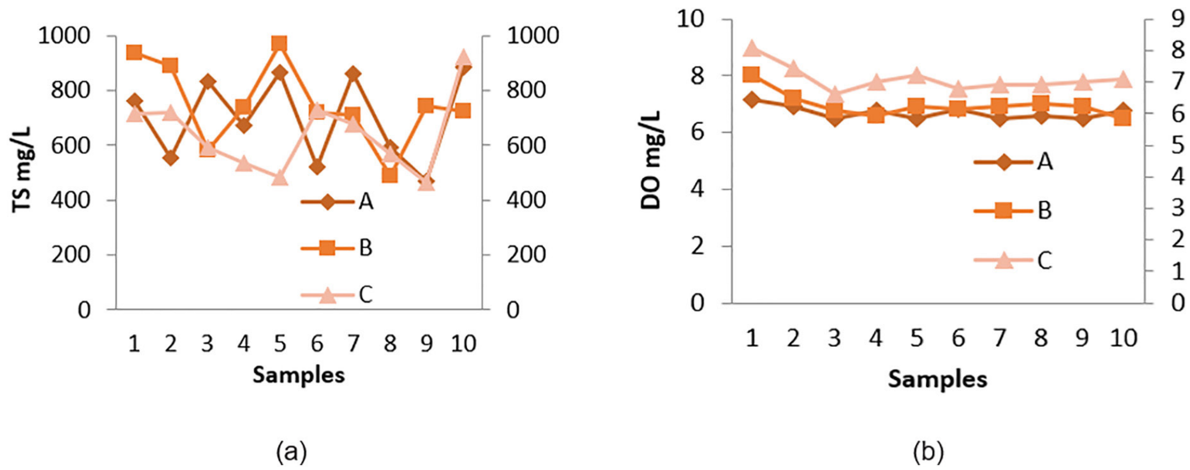

Figure 7: Analysis of (a) TS (b) DO measurements of the samples ("A, B, C" industry).

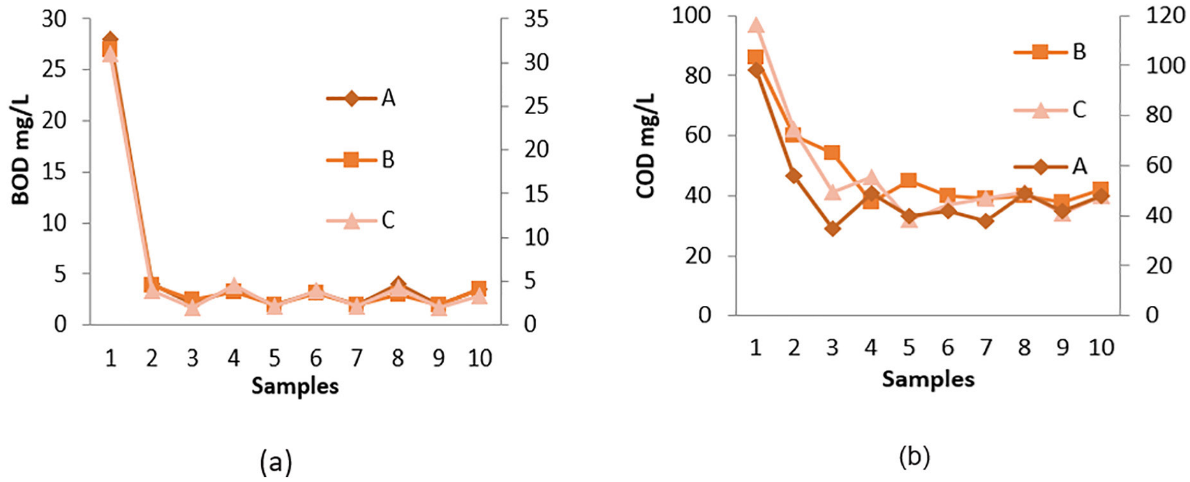

Figure 8: Analysis of (a) BOD (b) COD measurements of the samples ("A, B, C" industry).

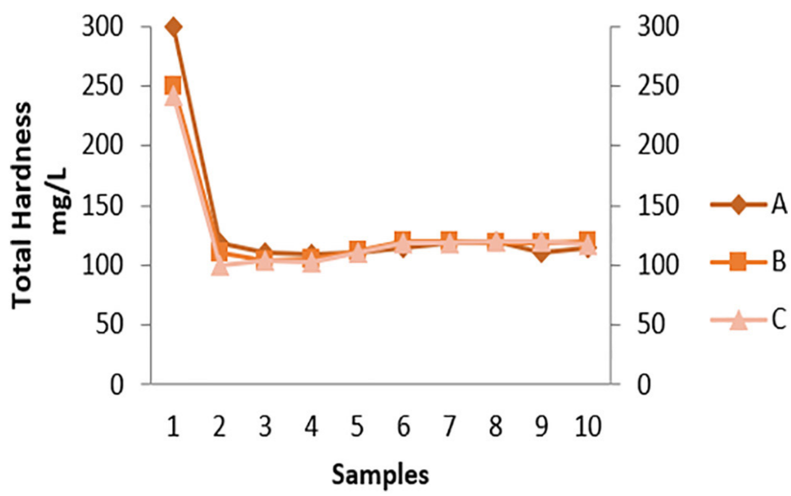

Figure 9: Analysis of TH measurements of the samples ("A, B, C" industry).

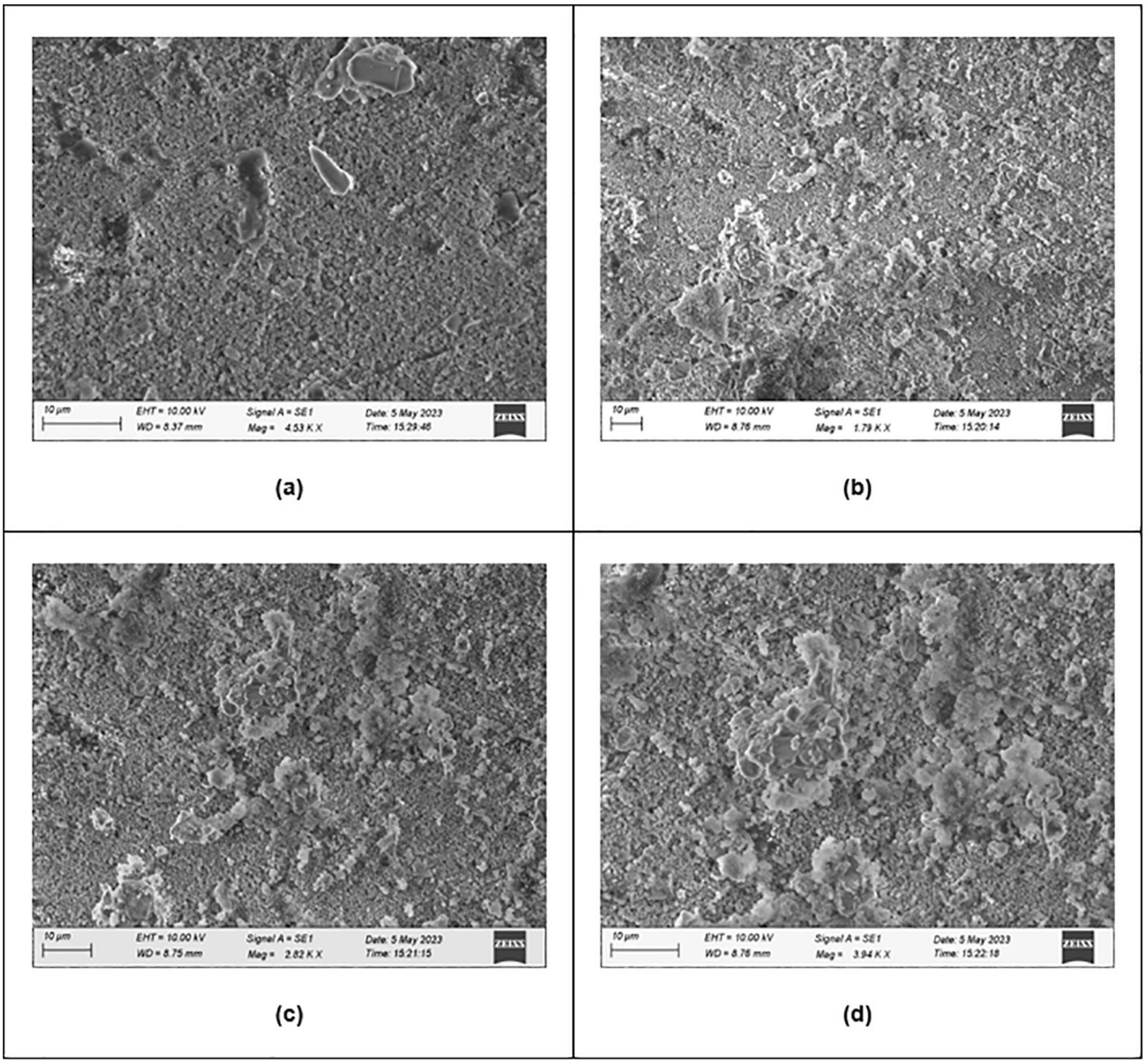

Figure 10: SEM Analysis- Surface of the α-Al2O3 Support layer- 10 micron Image (a) Before filtration (b) "A" sago industry sample 1 after filtration (c) "B" sago industry sample 1 after filtration (d) "C" sago industry sample 1 after filtration.

3.4. SPSS analysis

Version 23.0 of the SPSS (Statistical Package for Social Science) software was used to analyze the data. BOD, COD, TH, N, P, and K are the parameters taken into consideration for this study. For agricultural purposes, the aforementioned independent variables must be chosen carefully. Since BOD is regarded as a potential parameter, it is crucial to predict how other parameters may affect the effectiveness of BOD removal. As a result, certain variables are considered independent and BOD is considered dependent. Figure 11 shows the comparison of observed and predicted value of BOD concentrations. The level of pollutant degradation and processing effect within a single cycle can be roughly estimated thanks to the projected values. Even though there may be a small gap between the true and anticipated values, this discrepancy only occurs in the first phase of the process.

3.4.1. SPSS analysis for A-sago industry

The R^2 for the observed model and predicted model are 0.997 and 0.996, independent variables explain 99.7% (observed) and 99.6% (predicted) of the variability of our dependent variable BOD, R value for observed and predicted data are 0.998a and 0.996a respectively. The ANOVA Table 3 shows that the independent variables statically predicts the dependent variables, $F(5,4) = 259.369$ (observed), $F(5,4) = 205.758$ (predicted), ($P < 0.001$).

This means the five variables are highly significant in influencing BOD removal. It may be utilized as a predictive model because the regression equation shows that the aforementioned regression factors significantly affect the dependent variables.

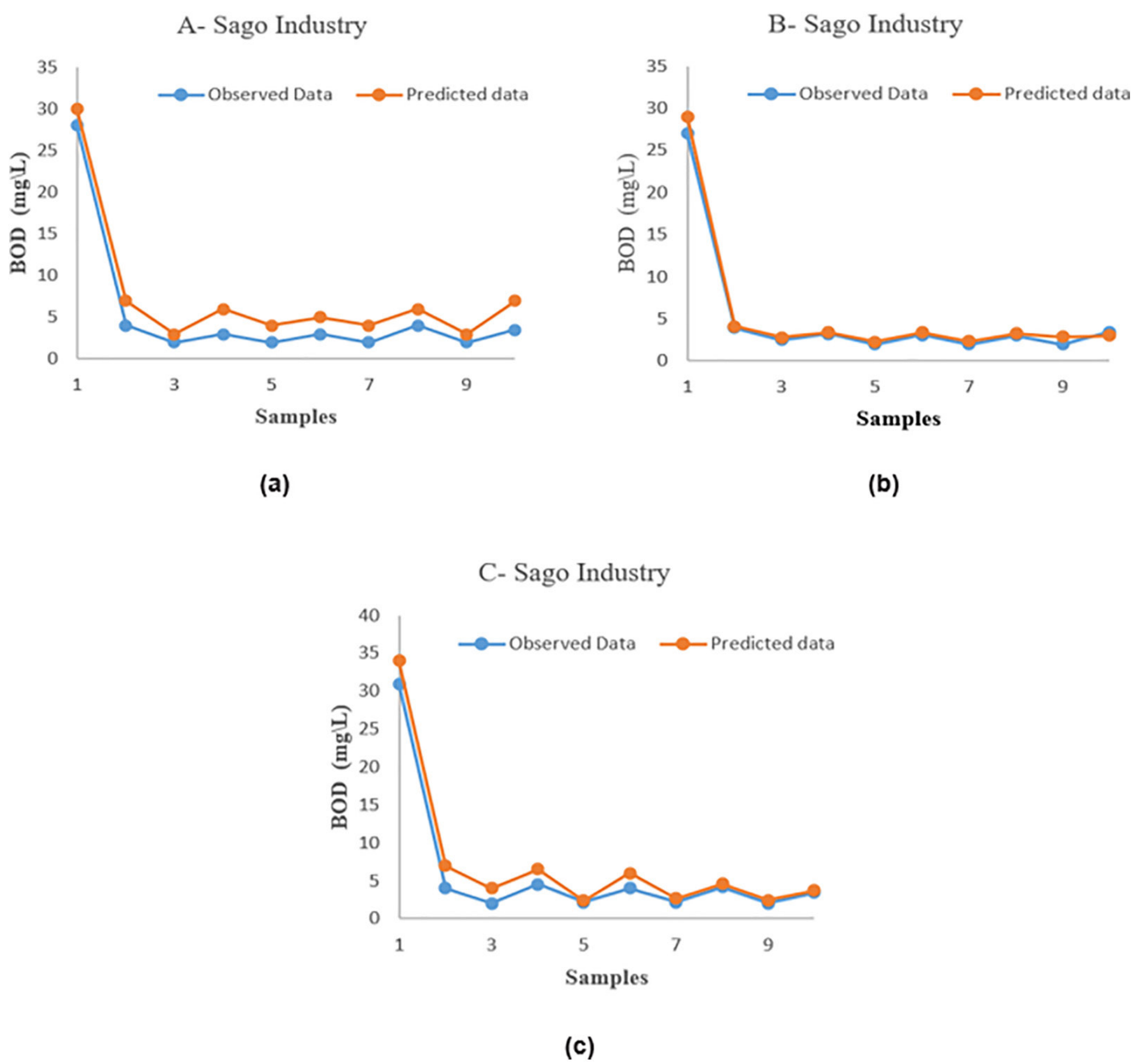

Figure 11: Comparison of Observed and Predicted BOD concentrations (a) A Sago Industries (b) B Sago Industries (c) C Sago Industries.

Table 3: Model summary – observed data and predicted data for the effluent BOD.

MODEL	A		B		C	
	OD	PD	OD	PD	OD	PD
R	0.998	0.998	0.997	0.998	0.997	0.998
R2	0.997	0.996	0.994	0.997	0.994	0.997
Adjusted R2	0.993	0.991	0.987	0.992	0.987	0.992
Std.error of estimate	0.6633	0.7510	0.8876	0.7291	0.8876	0.7291
Sum of Squares	570.541	580.244	527.924	605.683	527.924	605.638
df	5	5	5	5	5	5
Mean Square	0.440	116.049	105.585	121.128	105.585	121.128
F	259.69	205.758	134.010	227.867	134.010	227.867
p-value	<0.001	0.00	<0.001	0.00	<0.001	0.000

OD– Observed Data, PD– Predicted Data, Dependent Variable: BOD.

3.4.2. SPSS analysis for B-sago industry

The observed data and predicted data had R2 values of 0.994 and 0.997, respectively. Independent factors explain 99.4% (observed) and 99.7% (predicted). The R values is 0.997a and 0.998a correspondingly. The independent factors explain dependent variables statistically F (5,4) = 134.010 (observed), F (5,4) = 227.867 (observed), P < 0.001. COD, N, P, K and TH are well significant in influencing BOD removal. The resulting regression equation shows that the dependent variables are significantly impacted by the aforementioned regression parameters, making it suitable for use as a predictive model.

3.4.3. SPSS analysis for C-sago industry

The observed data and predicted data had R2 values of 0.994 and 0.997, respectively. Independent factors explain 99.4% (observed) and 99.7% (predicted) of the variability of our dependent variable BOD, with R values of 0.997a and 0.998a correspondingly. The ANOVA Table 3 reveals that independent factors explain dependent variables statistically F (5,4) = 134.010 (observed), F (5,4) = 227.867 (observed), P < 0.001.

It is observed form the above Table 3 that P value is in all three industries value is 0.000 which implies that the model estimated by the regression procedure is significant. The P values for the estimated coefficients of COD, N, P, K and TH indicate that they are significantly related to BOD removal efficiency. This behavior indicates that the after treatment tested values were in equitable agreement with the predicted values with a 95% confidence interval, and it clearly showed that the model could adapt to the after treatment tested results, conforming the validity and adequacy of the models.

3.5. Optimization of CNN model

All layers of the neural network are developed and trained using the PYTHON programming neural network tool. One input matrix with up to seven inputs for each of the three outputs is used to train the CNN. To improve network training performance, the input data is pre-treated before training. At now, to establish the appropriate number of hidden layers and neurons in each layer, different network designs need be explored, and the performance of each network should be evaluated. A network that has too few hidden layers and neurons may be underfitted, even though it could provide a good generalization. On the other hand, a high number of hidden layers may enhance network overfitting while reducing the training error. Trial and error was used to identify the best network topology for each output after testing a number of different configurations. The number of inputs, hidden layers, and neurons in the hidden layer were among the configuration options.

The low R2 value indicates the complexity of the system, as it cannot be modeled using only one input parameter. In comparison, reported high R2 values while using a one input and one output CNN structure. However, the high performance occurred due to the large number of neurons used in their model, which led to overfitting and reduced model generalization. The best input performances in predicting the effluent BOD

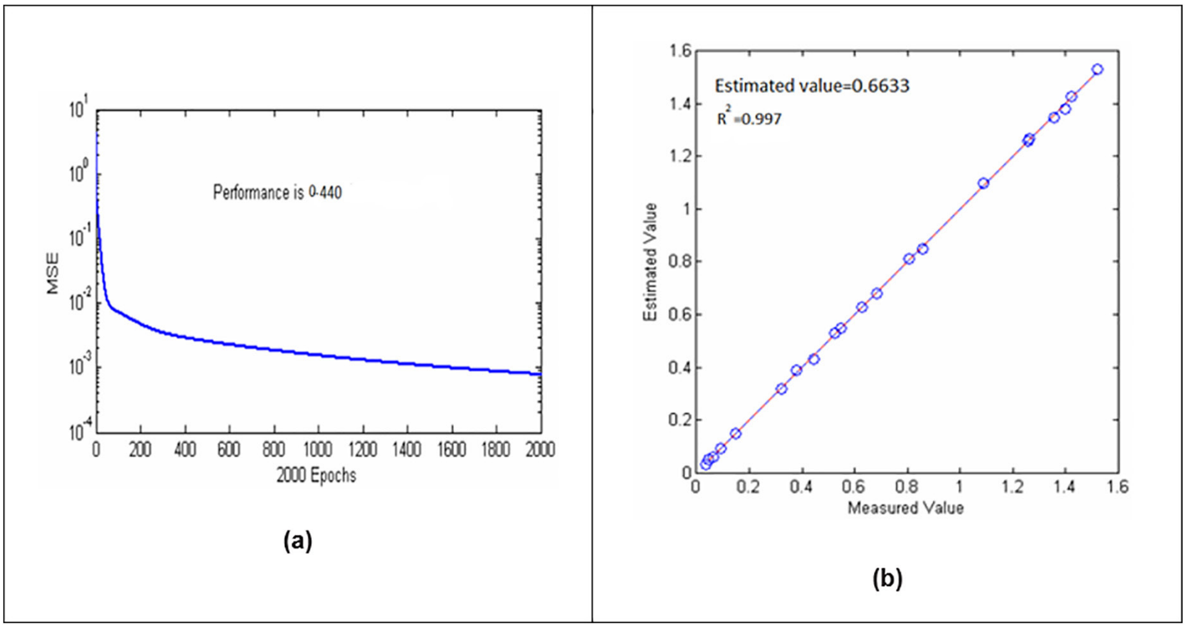

Figure 12: (a) Training performance curve. (b) Correlation between estimated value and measured value for "A" industry.

were obtained for the BOD, COD, TSS, N, P and K. The next step was to train three input and one output CNN models. It should be noted that every possible combination of three input parameters was considered with different numbers of hidden layers.

Figure 12 displays the estimated value and CNN training performance. The accuracy of the model is demonstrated by the R2-value of 0.997 and the MSE of 5.95 in Figure 12. the results for every system's optimized value. The modeling yielded reliable findings, with a mean square error (MES) of around 5.9 over 2000 epochs. The model may be utilized to regulate wastewater treatment, as shown in Figure 12b, which also demonstrates that the anticipated values and observed values have almost comparable patterns. Figures 13 and 14 presented the training performance and Correlation between estimated value and measured value for "B" "C" Industry respectively.

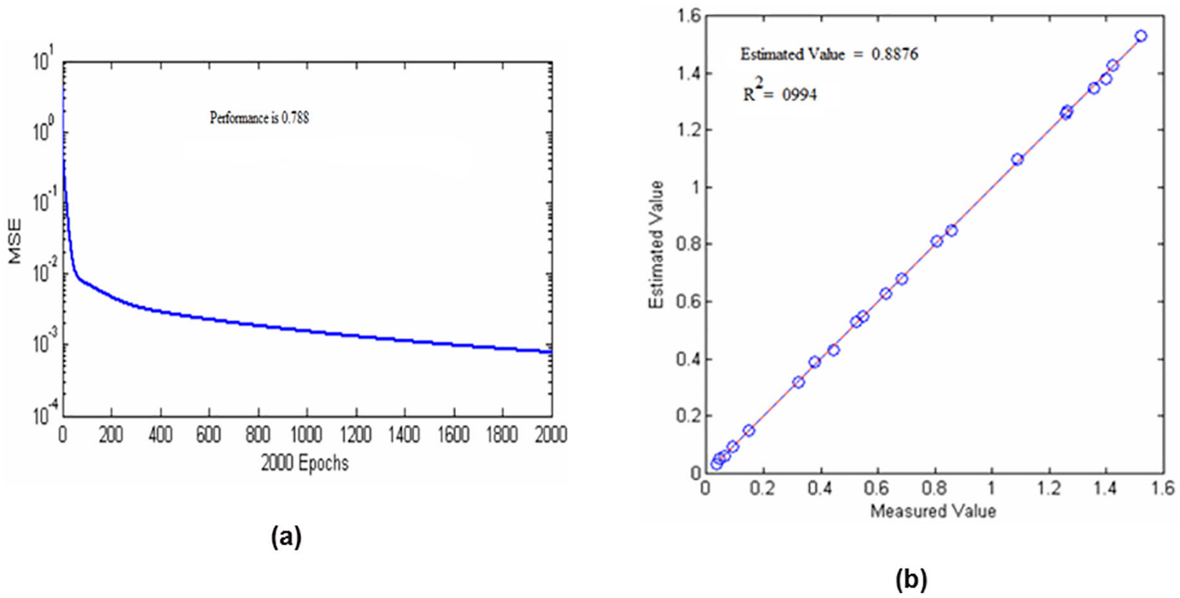

Figure 13: (a) Training performance curve. (b) Correlation between estimated value and measured value for "B" industry.

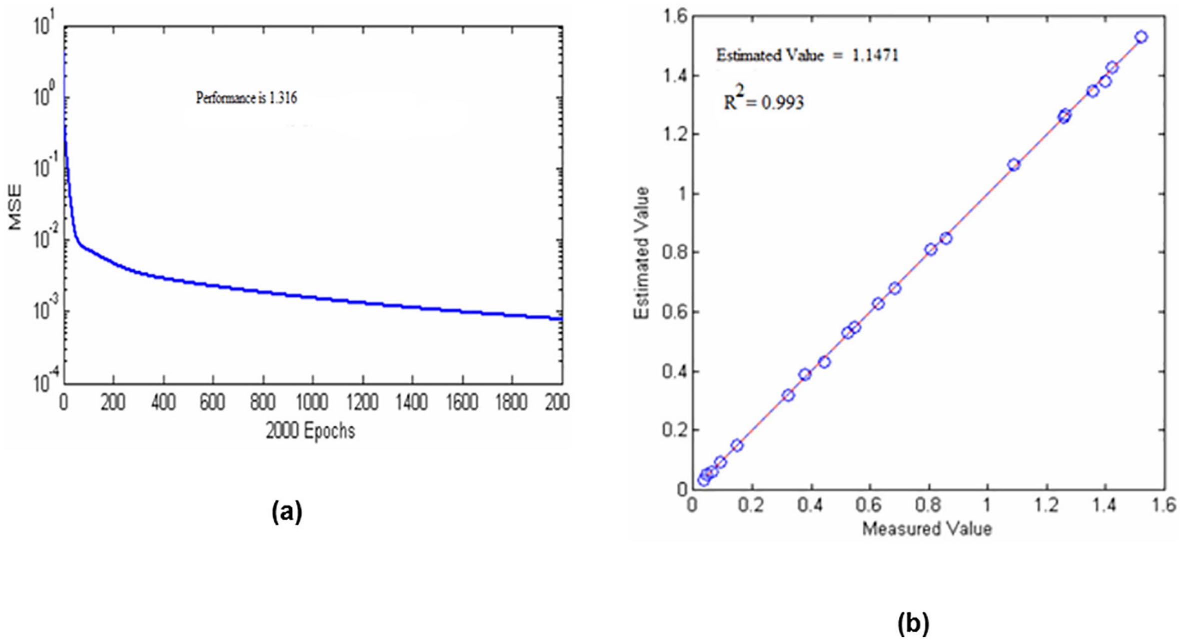

Figure 14: (a) Training performance curve. (b) Correlation between estimated value and measured value for "C" industry.

The model's performance is evaluated using two statistical measures: the mean square error (MSE) is 5.4 for the "B" industry and 5.43 for the "C" industry, and the correlation coefficient (R2 is 0.994 for the "B" industry and R2 is 0.993 for the "C" industry) show that the "B" and "C" model is accurate. The distribution of the CNN model's outputs, which is entirely in line with the distribution of the observed data, demonstrates how well the model can forecast the removal efficacy of BOD in the pollutants in wastewater treatment.

4. CONCLUSION

The various treatment methods are conducted in this study including pebbles and gravel, fine sand, coconut coir, charcoal and α-Al2O3 ceramic membrane used in the filtration model. The proposed vertical model is better than the other treatment process and the proposed model was recorded that the better removal percentage of BOD in the sago wastewater. The α-Al2O3 ceramic membrane provides an eco-friendly solution for wastewater treatment. The quality study showed that the parameters like pH, TDS and TS are within the permissible limit and the average percentages of pH, TDS and TS are 16%, 45% and 52% respectively. The percentage removal efficiency of TSS, BOD and COD, in "A" sago industry (65.28%, 68.21% and 67.02%), (69.26%, 67.25% and 67.68%) in "B" sago industry and (69.68%, 69.37% and 67.66%) in "C" sago industry respectively in treated effluent. The maximum reduction in TDS and TS values were 34.02% and 58.8% in "A", 33% and 60% in "B", 32% and 63% in "C" respectively. Turbidity, Total hardness and Total Alkalinity were found to be within the permissible limits. The average percentage is 65%, 58% and 56% are achieved and all the samples are within the permissible limit of water standards (WHO and BIS). Based on the investigations, the well and borewell waters in 2.5 – 5 km water samples from the study area the physical and chemical parameters are below the permissible limits in all areas in general with few exceptions here and there. The Regression Modelling investigations concluded that the developed model fit and significant. The equation suitably fitted to the parameters like BOD removal. The R^2 value for predicted data was 0.98 and the R^2 value for the after treatment observed data was 0.99. ANN model was performed better for the total data was randomized as training performance. This study concludes that a combination of any different parameters of input it provides better performance in predicting the BOD removal. The correlation coefficient (R^2 is 0.99 for "A" industry, R^2 is 0.994 for "B" industry and R^2 is 0.993 for "C" industry) and Mean Square Error (MSE is 5.9 for "A" industry, MSE is 5.4 for "B" industry and MSE for 5.43 for "C" industry) with 2000 epochs, indicate that the model is accurate.

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