Pollution Analysis and Instream Treatment For Improvement of Canoli Canal

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Abstract— Canoli canal or E K canal is a manmade water body flowing through Kozhikode city, constructed in 1848. The canal connects Korapuzha River in the north and the Kallai River in the south. Water quality parameters is tested in different months December, January, February in kallai, kalluthan kadavu, Arayidathupalam, Sarovaram and Korapuzha. The parameters examined are pH, turbidity, conductivity, COD, BOD, chloride, ammonia, nitrate, phosphate, sulphate, iron, fecal coliform and total coliform. Thus inorder to reduce the pollutant load the canal water is passed through a constructed wetland. This project aims at checking the efficiency of this instream treatment in reducing pollutant load.

Key Words— Canoli canal, Constructed wetland, Diversion canals, Instream treatment, Pollutant load, Removal efficiency, Water quality parameters

1 Introduction

The Canoly Canal is part of the West Coast Canal system and is situated in the city of Kozhikode. The canal is 11.4 km long, the width ranges from 6m to 20m and water depth in the peak rain period varies from 0.5 to 2m. The canal connects the Kallayi River in the south and the Mangala River in the north, passing through Kottuli wetlands and Perunthuruthi wetlands.The Canal is oriented to direct inflow from 4 water bodies Mangala River, Perunthuruthi Wetlands, Kottuli Wetlands and Kallayi River. The highest elevation is found at Kunduparamba and lowest at Kottuli.Topography of the region shows that the stretch of the canal from Elathur to Kunduparamba falls in the Mangala river basin, and the rest, from Kunduparamba to Kallayi, falls in the Kallayippuzha basin. The canal passes through the ridge between the two basins between Puthiyangadi and Kunduparamba; this is also the point that has maximum depth of the canal, minimum water depth and minimum tidal fluctuations.The depth of the canal ranges from 3.8m to 11m [1].

Canoli Canal, which is an artificially constructed canal, is flowing through the heart of Kozhikode city and is heavily polluted with the untreated sewage discharging into the water body. The source of pollution includes waste from hospitals, hotels, garages, timber industries, slaughter houses as well as residential areas. Many drainage outlets are connected to the canal and the water body receives the storm water, household grey water and sewage. All these activities contribute to the poor condition of the canal water [2].

2 Methodology

2.1 Sample collection

Five sampling points is selected in canoli canal. The points are kallai which is the starting point of canoli canal, Arayidathupalam, Kalluthan kadavu, Sarovaram and Korapuzha near eranjikkal which is the end point of canoli canal as shown in fig 1.

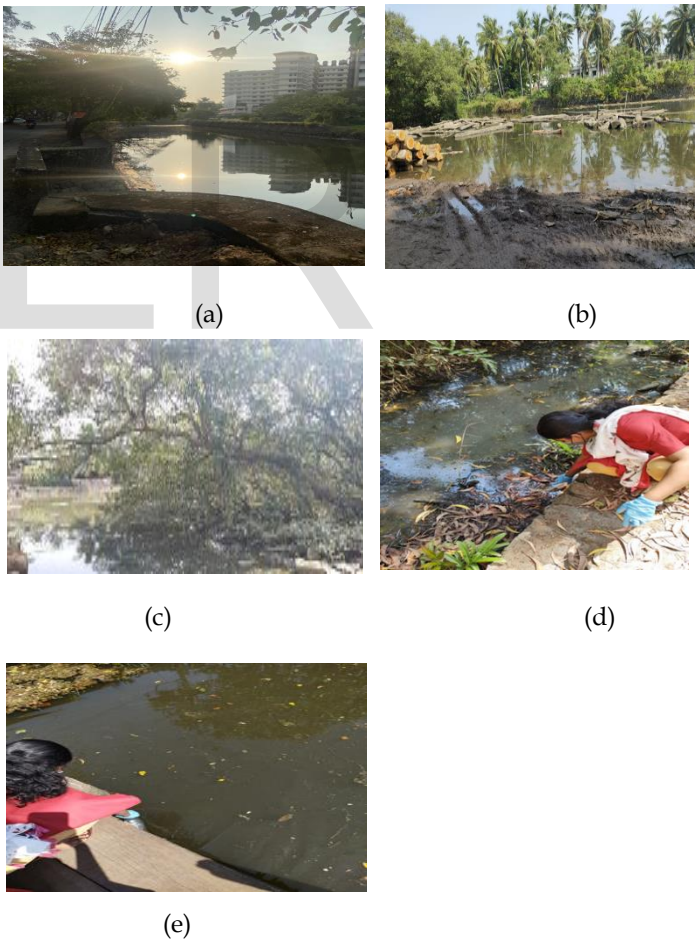

Fig.1 Sample collected from **(a)** Arayidathupalam **(b)** Kallai **(c)** Kalluthankadavu **(d)** Sarovaram **(e)** Korapuzha

Sample has been collected from these data points during months of December, January and February to analyse the seasonal variations.

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2.2 Testing Of Samples

The collected sample has been tested for various parameters such as pH, turbidity, conductivity, COD, BOD, chloride, ammonia, nitrate, phosphate, sulphate, iron, fecal coliform and total coliform.

3 Results And Discussions

The result of water quality parameters tested at five different locations through which canoli canal flows such as Kallai which is the starting point of canoli canal, Kalluthankadavu, Arayidathupalam, Sarovaram and Korapuzha river mouth near Eranjikkal which is the end point during the months of Decemeber, January, February is shown in table 1, 2 and 3 respectively. Here S1 represents the sampling point 1 which is Korapuzha, S2 represents the sampling point 2 Sarovaram, S3 represents sampling point 3 Kalluthan kadavu, S4 represents sampling point 4 Arayidathupalam and S5 represents sampling point 5 Kallai.

TABLE 1
Water Quality Parametrs In December

Parameters	S1	S2	S3	S4	S5
Ph	6.1	6.68	7.14	6.75	6.6
EC (ms/cm)	14.2	5.3	18.8	4.8	4.2
Chloride (mg/l)	19524	1784	5452	1487	21246
Turbidity (NTU)	16.2	16	20	17	12
COD(mg/l)	102	147	92	136	140
BOD(mg/l)	22.5	28	25	37	18
Ammonia(mg/l)	ND	15	16	15	0.02
Nitrate(mg/l)	ND	1.1	2.2	0.41	0.42
Phosphate(mg/l)	ND	0.08	0.37	0.08	0.1
Iron(mg/l)	0.1	BDL	0.66	BDL	0.65
Sulphate(mg/l)	251	6.3	14	5	365
Fecal Coliform (CFU/100ml)	240	240	960	180	250
Total Coliform (CFU/100ml)	220	340	1120	1320	290
E-Coli	Positive	Positive	Positive	Positive	Positive

Turbidity in water near sample collected from Kalluthankadavu obtained is 17 NTU which is higher beacause of high discharge of hotel waste and hospital waste into canal water near Kalluthuankadav also a public drain is opened to it. Sample collected from Arayidathupalam has high BOD of about 37mg/l point has high BOD and Ammonia, nitrate and phosphate found in water sample near to Kalluthankadavu is 16 mg/l, 2.2mg/l and 0.37 mg/l respectively which is higher whereas these are not detectable in water near to Korapuzha. Sulphate content of water near to kalli is 365 mg/l which is higher. Presence of microbes is higher in both Kalluthan kadavu and Arayidathupalam and low in Korapuzha.

pH in Korapuzha obtained is 6.1, Sarovaram is 6.68, Kalluthan kadav is 7.14, Arayidathupalam is 6.75 and Kallai is 6.6. Here water in canoli canal near Kalluthankadavu has high pH. Conductivity in Korapuzha is 14.2 ms/cm, in sarovaram is5.3 ms/cm, in Kalluthankadavu is 18.8 ms/cm, in Arayidathupalam is 4.8 ms/cm and in Kallai is 4.2 ms/cm. Here conoli canal water near Kalluthankadavu has high conductivity. Canoli canal water near Korapuzha has chloride content of 1954 mg/l, in Sarovaram is 1784 mg/l, in Kalluthankadavu is 5452mg/l, in Arayidathupalam is 1487 mg/l and in Kallai is 21246mg/l. It is clear that canoli canal joining Kallai river has high chloride content.

TABLE 2
Water Quality Parametrs In January

Parameters	S1	S2	S3	S4	S5
pH	7.42	6.47	6.97	6.99	7.23
EC (ms/cm)	22.3	26.67	25	18.4	4.41
Chloride (mg/l)	20415	3421	5744	7200	29871
Turbidity (NTU)	18.7	25.5	22.4	24.3	19.7
COD(mg/l)	131.7	175.6	158.2	174.8	192
BOD(mg/l)	37	29.9	19.8	40	25
Ammonia(mg/l)	ND	0.2	0.051	0.255	0.187
Nitrate(mg/l)	ND	7.13	6.05	6.17	2.58
Phosphate(mg/l)	ND	1.89	1.23	0.18	1.46
Iron(mg/l)	0.56	0.12	0.79	BDL	0.16
Sulphate(mg/l)	2508	112	58.3	78.4	3459
Fecal Coliform (CFU/100ml)	278	194	1070	298	5800
Total Coliform (CFU/100ml)	320	256	1035	447	8060
E-Coli	Positive	Positive	Positive	Positive	Positive

Canoli canal water in Arayidathupalam sampling point has high BOD content of about 43 mg/l. Ammonia is higher in water near to Kalluthankadavu is 17.291 mg/l and are not detectable in water near to Korapuzha. Nitrate and phosphate found in water sample near Sarovaram is 2.1 mg/ and 0.844 mg/l respectively which is higher and is not detectable in water near to Korapuzha.

The data also revealed that, the highest proportion of bacterial species were noticed in the samples collected from Kaluthankadavu and Kallai. When these sites were surveyed, it was found that sewage disposal practices in that area are very poor. Also Kaluthankadavu bridge site is a slum area were municipal drainage facilities are not provided. Low bacterial counts were observed in the samples collected from Korapuzha

(Erajikkal area) where well established municipal drainage system was present.

TABLE 3
WATER QUALITY PARAMETRS IN FEBRUARY

Parameters	S1	S2	S3	S4	S5
pH	7.42	6.47	6.97	6.99	7.23
EC (ms/cm)	22.3	26.67	25	18.4	4.41
Chloride (mg/l)	20415	3421	5744	7200	29871
Turbidity (NTU)	18.7	25.5	22.4	24.3	19.7
COD(mg/l)	131.7	175.6	158.2	174.8	192
BOD(mg/l)	37	29.9	19.8	40	25
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Total coli-from(CFU/100ml)	320	256	1035	447	8060
E-Coli	Positive	Positive	Positive	Positive	Positive

pH in Korapuzha obtained is 7.42, in Sarovaram is 6.47, in Kalluthankadav is 6.97, in Arayidathupalam is 6.99 and Kallai is 7.23.Water in canoli canal near Korapuzha has high pH. Conductivity in Korapuzha is 22.3 ms/cm, in Sarovaram is 26.67 ms/cm, in Kalluthankadavu is 25 ms/cm, in Arayidathupalam is 18.4 ms/cm and in Kallai is 4.41 ms/cm. Here conoli canal water near Sarovaram has high conductivity. Canoli canal water near Korapuzha has chloride content of 20415 mg/l, in Sarovaram is 3421 mg/l, in Kalluthankadavu is 5744 mg/l, in Arayidathupalam is 7200 mg/l and in Kallai is 29871mg/l.

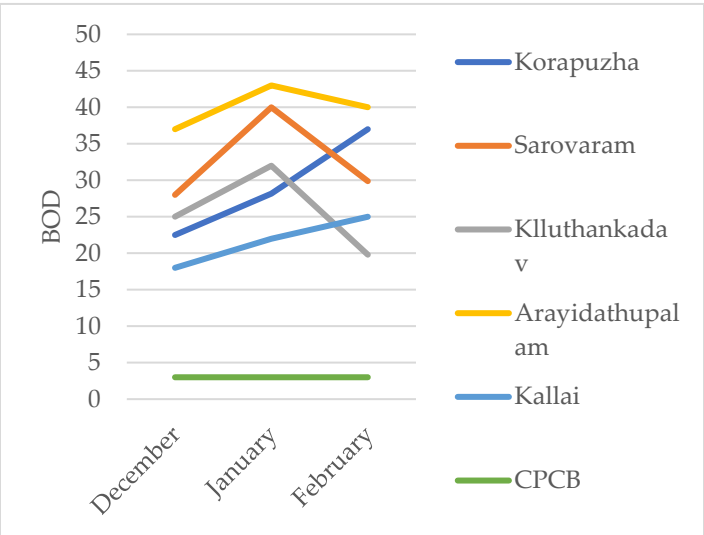

Fig. 2 variation in BOD compared with CPCB standards

Fig.2 shows variation of BOD compared with CPCB classification B. Class B of CPCB belongs to those which are used for outdoor bathing where Biochemical Oxygen Demand 5 days 20°C 3mg/l or less [4]. Here it is clear that BOD of all sampling point tested during all the three months falls above the CPCB limit. Sample collected from Arayidathupalam, Kalluthankadavu and Sarovaram shows a peak value in month of January

Fig 3 shows variation of total colliform compared with CPCB classification B. Class B of CPCB belongs to those which are used for outdoor bathing where total Coliforms Organism MPN/100ml shall be 500 or less.

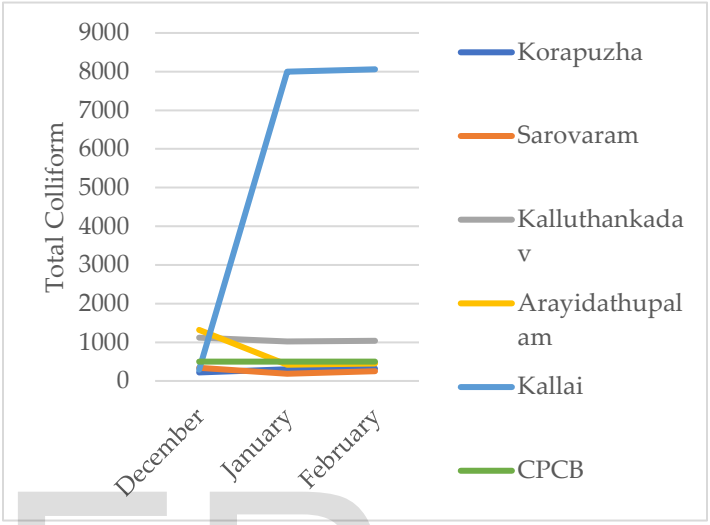

Fig. 3 Variation in total colliform compared with CPCB standards

Here it is clear that total colliform of sample collected from Sarovaram and Korapuzha falls below the CPCB standard during the three months and during the month of January sample collected from Kallai shows peak value and then it become stable. Sample collected from Arayidathupalam doesn't show much variations and falls above CPCB standards.

TABLE 4
TESTING OF INFLOW SAMPLE

Parameters	Sample from Eranjipalam
pH	6.37
EC (ms/cm)	21.79
Chloride (mg/l)	3892
Turbidity (NTU)	22.5
COD(mg/l)	188
BOD(mg/l)	40
Ammonia(mg/l)	1.3
Nitrate(mg/l)	7.3
Phosphate(mg/l)	1.37
Iron(mg/l)	0.13
Sulphate(mg/l)	124
Fecal coliform (CFU/100ml)	245
Total colifrom(CFU/100ml)	324
E-Coli	Positive

Sample is collected from an inflow mouth at eranjipalam and is tested as shown in table 4 inorder to understand its parameters. From this data it is clearly evident that there exist

most worst conditions in inflow point as it contain high BOD content.

3.1 Development of Constructed Wetland

A constructed wetland is a shallow basin filled with some sort of filter material (substrate), usually sand or gravel, and planted with vegetation tolerant of saturated conditions. Wastewater is introduced into the basin and flows over the surface or through the substrate, and is discharged out of the basin through a structure which controls the depth of the wastewater in the wetland [3].

An artificial channel for diverting water from one place to another is termed as a diversion canal. In this project a diversion canal is constructed parallel to canoli canal in areas of more polluted. Also in areas of inflow a diversion canal is constructed to divert the inflow to diversion canal thereby not entering the main canal.

Regulator gates are commonly used to control the incoming flow. Regulator gates are being constructed near the inflow mouths and inlets and canal joining the diversion canal

A solar pump may be used to pump the water from canoli canal to diversion canal which helps in flow of water.Aerators are of many types such as spray aerators, cascade aerators etc. Here a cascade aerator may be provided to maintain DO.

3.2 Representation of Instream Treatment

A schematic representation of instream treatment is shown in fig 4. The canal water is diverted to a diversion canal constructed parallel to main canal. A regulator gate is constructed for regulating the flow in canal.

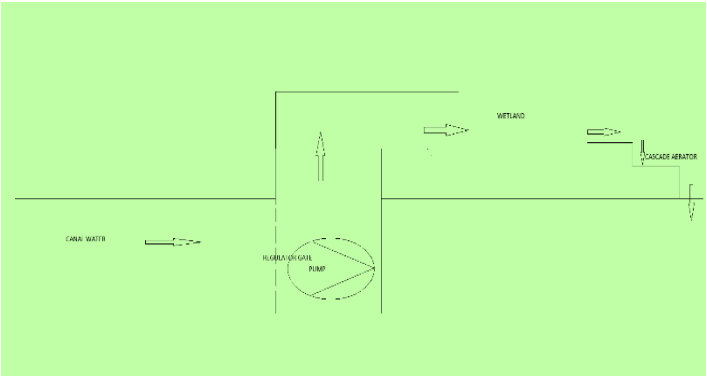

Fig. 4 Representation of instream treatment

A pump is constructed which may be a solar for diverting the water from main canal. Then the water is allowed to pass through free water surface constructed wetlands. As water passes through it most of the impurities get removed after that the water is allowed to pass through an aerator mainly a cascade type aerator to maintain DO. After these process the water is allowed to enter the main canal. These instream treatment mechanism is constructed at various areas through which canoli canal flows. The inflow to canoli canal is also divereted to diversion canal thus it is prevented from falling to canoli canal.

3.3 Area Calculation

A preliminary estimate of the land area required for an FWS wetland can be obtained from Table 5 of typical areal loading rates presented below [5].

TABLE 5
TYPICAL AREAL LOADING RATES

Constituent	Typical Influent Conc. (mg/L)	Target Effluent Conc. (mg/L)	Mass Loading Rate (lb/ac/d)
Hydraulic loading (in/d)	0.4-4		
BOD	5-100	5-30	9-89
TSS	5-100	5-30	9-100
NH3/NH4 as N	2-20	1-10	1-4
NO3 as N	2-10	1-10	2-9
TN	2-20	1-10	2-9
TP	1-10	0.5-3	1-4

Peak value of different water quality parameters tested at five sampling points is being summarized and is shown in table 6.

TABLE 6
PEAK VALUE FOR AREA SELECTION

Location	Flow rate (m3/d)	Parmeter	Peak value(mg/l)
Sarovaram	300	BOD	32
		Ammonia	10
		Nitrate	3.4
		Phosphate	0.93
Kalluthan-kadav	300	BOD	25
		Ammonia	11
		Nitrate	3.3
		Phosphate	0.68
Arayida-thupalam	300	BOD	40
		Ammonia	9
		Nitrate	2.8
		Phosphate	0.12
Korapuzha	300	BOD	29
		Ammonia	
		Nitrate	
		Phosphate	
Kallai	300	BOD	22
		Ammonia	0.1
		Nitrate	1.2
		Phosphate	0.95

The requied area for development of wetland at different points through which canoli canal flow is being calculated and is shown in table 7.

The maximum area selected for sarovarm is 5.49 ha, for kalluthankadav is 6.04 ha, for arayidathupalam is 4.94 ha, for korapuzha is 0.96 ha, for kallai is 0.72 ha.

TABLE 7
SELECTED AREA

Location	Parmeter	Load (g/d)	Mass Loading Rate (g/ha/d)	Area (ha)	Required Area (Highest of all)
Sarovaram	BOD	9600	9109	1.05	
	Ammonia	3000	547	5.49	5.49
	Nitrate	1020	1093	0.93	
	Phosphate	279	547	0.51	
Kalluthankadav	BOD	7500	9109	0.82	
	Ammonia	3300	547	6.04	6.04
	Nitrate	990	1093	0.91	
	Phosphate	204	547	0.37	
Arayidathupalam	BOD	12000	9109	1.32	
	Ammonia	2700	547	4.94	4.94
	Nitrate	840	1093	0.77	
	Phosphate	36	547	0.07	
Korapuzha	BOD	8700	9109	0.96	0.96
	Ammonia	0	547	0.00	
	Nitrate	0	1093	0.00	
	Phosphate	0	547	0.00	
Kallai	BOD	6600	9109	0.72	0.72
	Ammonia	30	547	0.05	
	Nitrate	360	1093	0.33	
	Phosphate	285	547	0.52	

Following equation can be used for Area Calculation
Waste water flow = (Population Equivalent × Flow rate) / 1 km area
Area = (Waste water flow × Influent concentration)/ Mass loading rate

3.4 Efficiency Calculation

Efficiency of the wetland is calculated by passing the canal water through the constructed models and then testing BOD and thus calculating the removal efficiency. Fisrt one is the model of constructed wetland and second one is the layer of gravel at bottom and sand at top as of same length, breadth and thickness of wetland model. Raw water is being poured to the models and is being left for testing the effluent water BOD removal efficiency after 1 and 2 weeks.

TABLE 8
REMOVAL EFFICIENCY

Time	Influent (mg/L)	Effluent (mg/l)		Removal Efficiency (%)	
		With plants	Without plants	With plants	Without plants
After 1 week	40	25	30	37.5	25
2nd week	40	19	28	52.5	30

As shown in table 8 removal efficiency obtained from model with plants is about 37.5% and that of without plants is about 25% after 1week.Removal efficiency obtained from model with plants is about 52.5 % and without plants is about 30% after 2 weeks.

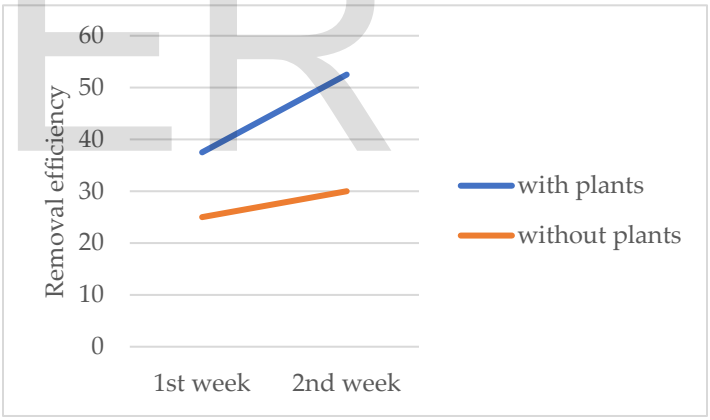

Fig. 5 Comparison of removal efficiency of wetlands

Fig.5 shows that removal efficiency of wetland with plants is greater than that of wetland without plants. The removal efficiency increases from week 1 to week 2 in both the models.

4 CONCLUSION

In the present study water sample is collected from canoli canal during months of December, January and February from Kallai, Kaluthankadavu, Arayidathupalam, Sarovarm and Korapuzha. From the results obtained it can be concluded that pollutants are more at southern side of canoli canal. It can be observed that microbiological parameters obtained at Kallai and Kalluthan kadav side is about 8000 MPN due to public drains open to canal in these sides and also discharge of hospital waste, hotel waste and domestic waste make the canal water

more polluted and deadly. In post monsoon season pollutants are comparatively less and Nutrient load obtained at Sraovaram, Kalluthankadavu and Kallai is about 1-20 mg/l which is higher. Since aerators are recommended at all locations, ammonia load will be reduced by 50% hence area for ammonia removal will be reduced and removal efficiency obtained by using wetland is 52.5 %. Thus treatment of canoli canal water by passing through constructed wetland is a better option than constructing a treatment plant because more than half of the pollutant load reaching the Kallai river can be reduced.

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