Impact of Canal Recharge on Groundwater Quality of Kolayat Area, District Bikaner, India

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Abstract: Rajasthan is one of the water scarce states of India where the annual average rainfall varies from less than 100 to 1000 mm. Kolayat area of district Bikaner located in western part of the state, receives average annual rainfall of 275 mm. Owing to the less rainfall of this low magnitude, the water availability problem in the Kolayat area is critical in comparison to many other parts of the state. The water requirement, of the area, is mainly met by Indira Gandhi Nahar Project (IGNP) canal. The groundwater quality of the area through which IGNP canal passes has been studied to understand the effect of canal recharge on groundwater and subsurface movement of recharge pathways. The canal trends in NE-SW direction and flows towards SW. The study has been carried out across the canal 40 km in the eastern and 20 km in the western direction. The depth to water varies between 10 and 55 m bgl. The water levels are shallow in western direction and upto Bajju in eastern direction from the canal. The water levels become deeper as one moves towards eastern direction. This suggests that the groundwater regime receives recharge from the canal towards western direction and upto Bajju in eastern direction. The groundwater flow directions obtained from water table contours also reveal the presence of groundwater mound in the vicinity of the canal. The EC of the canal water is 302 µS/cm where as the EC of groundwater varies from 563 µS/cm to 23600 µS/cm. The EC of groundwater along the canal varies from 563 µS/cm (Bajju) to 1916 µS/cm except Modayat where as EC is high away from the canal. Water quality analysis confirms the same result as interpreted from groundwater contours. The groundwater of the area has high calcium, magnesium, sodium, potassium, chloride, sulphate, they range upto 634, 787, 5890, 1015, 7908, 2650 mg/L respectively. Further, fluoride in the areas around Chak 4 GMR (3.8 mg/L), Bajju (1.93 mg/L), Godu Krishi farm (4.12 mg/L), Godu village (1.93 mg/L) exceeds the permissible limit for drinking purpose. The study also reveals that recharge from IGNP canal has a long term influence in the study area where groundwater is withdrawn for various activities.

Keywords: Kolayat, Groundwater, IGNP, Rainfall, Water Quality

1 INTRODUCTION

The stage of ground water development in district Bikaner district is 94.65 %, which indicates that the annual ground water draft and recharge are nearly equal. In district Bikaner out of 5 blocks, 2 falls under “Over-exploited” category, 1 blocks under “Critical” category, 2 blocks under “Safe” category [1]. The Kolayat area falls under safe category due to less development of groundwater. The main ground water related problem in the area, is its salinity. The study area extends with a major irrigation project called Indira Gandhi Nahar project (IGNP). This is one of the most enormous projects (649 Km long) in the world aiming to transform the desert waste into agriculturally productive area. The water supply to IGNP is through 204 km long Indira Gandhi Feeder, takes off from Harike barrage, which lies on Sutlej River [3]. The main Indira Gandhi Canal enters the district of Bikaner north of village Bhansar and it passes through Khagabera, Lakharwara, Sisardesar Chattargarh, Sattasar, Siasar, Prithiraj Ka Bere, Karmisar and Modayat. With the implementation of IGNP, which involved large amount of water into the system through canal network, the hydrogeological situation in the command area has undergone significant changes [4]. Prior to the introduction of canal irrigation, the ground water levels, in the area, were deep varying from 40 to over 50 m bgl. The ground water levels started rising consequent to the release of water in canals and introduction of irrigation. With the expansion of area under irrigation, the IGNP command area witnessed an alarming expansion of water logging and soil salinity. The areas around Kharbara, Dantor, Manaksar, Modayat, Charanwala Bhikampur etc. are more prone towards water logging [2]. In this study the effect of I.G.N.P canal on groundwater viz. water quality, groundwater contours in Kolayat block has been brought out. It is also tried to replicate the path of groundwater recharge movement to the aquifer.

2 STUDY AREA & HYDROGEOLOGY

The study area forms part of kolayat block of district Bikaner and lies in Survey of India Toposheet no. NG 43/1 between longitude 72° 14′ 25.79” E & 72° 46′ 52.38” E and latitude 28° 00′ 25.57” N & 27° 49′ 40.41” N as shown in Fig. 1. The IGNP canal trends NE-SW and flows in SW direction. The prominent places along the canal are Modayat and Bajju. The study has been carried out across the canal 40 Km in the eastern and 20 Km in the western direction. The study area located in the Thar Desert, has arid type climate with extremes of temperatures, erratic rainfall and high evaporation. Rainfall data (1973-2011) showed that the annual rainfall varies between 32 and 580 mm with mean value of 275 mm. The temperature varies from 48.5^{o} C in summer to 5^{o}C in winter. The atmosphere is generally dry except the monsoon period. Geologically the area is represented by the Naguar formation of Marwar supergroup. The main rock types are bricked colored sandstone, siltstone with gypsum and clay beds. The rocks of Nagaur formation are overlain by alluvial and deposits.

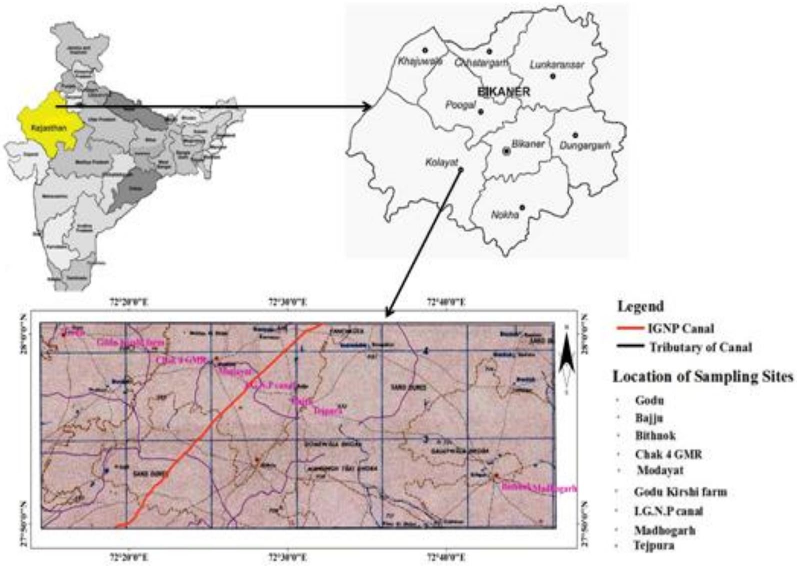

Fig. 1. Location Map of the study area

3 METHODOLGY

Groundwater levels are measured using water level sound recorder. Water samples from dug wells and main canal were collected in standard plastic bottles (period: April, 2013). The locations of the sampling sites are shown in Fig. 2. The physical parameters such as temperature, pH, electrical conductivity etc. were determined in the field using portable instruments. The water samples are analysed for their pH, EC, Ca^{++}, Mg^{++}, Na+, K+ CO_3^{--}, HCO_3^-, SO4 $^{--}$ and NO3$^-$, Cl$^-$, F$^-$.

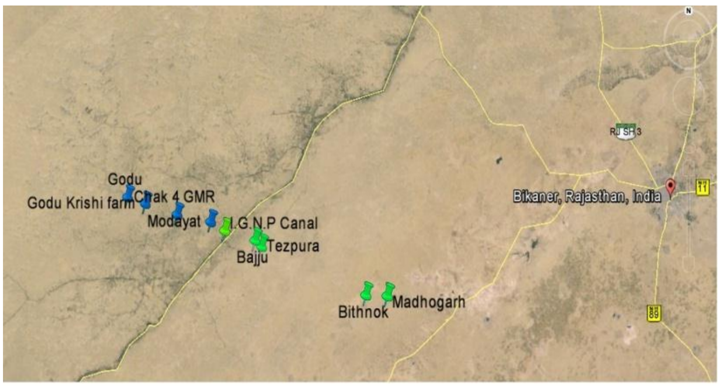

Fig. 2. Figure shows the location of sampling sites of Kolayat area, Distt., Bikaner

4 RESULTS AND DISCUSSION

The water levels were measured in the field and it was observed that groundwater level varies from 10 to 55 m (Fig. 3). The groundwater levels were available as the depth below ground surface; therefore, by measuring the R.L of the respective well location, these data have been converted to groundwater level above msl and then geo-referenced with respect to their latitude and longitude to get groundwater contours. Fig. 4 shows the groundwater contours maps depicting the groundwater flow direction towards west direction and upto Bajju in the eastern direction from the canal.

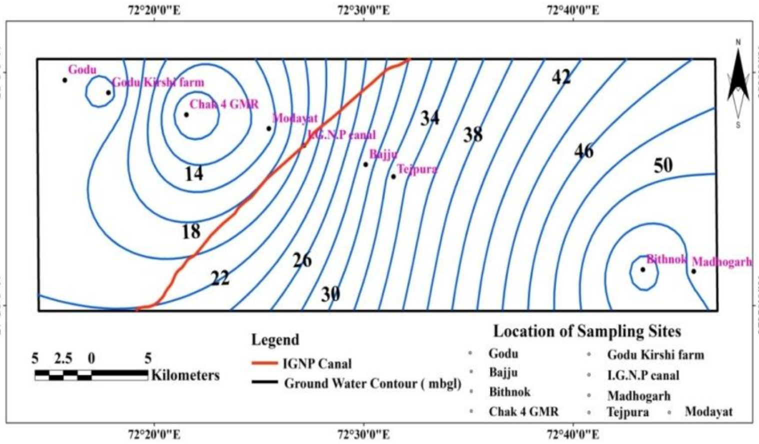

Fig. 3. Depth to water level map of the study area

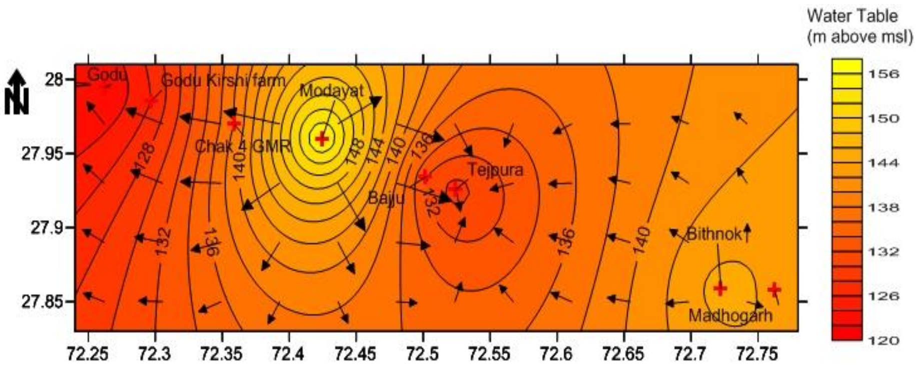

Fig. 4. Water table contours and flow direction of the study area

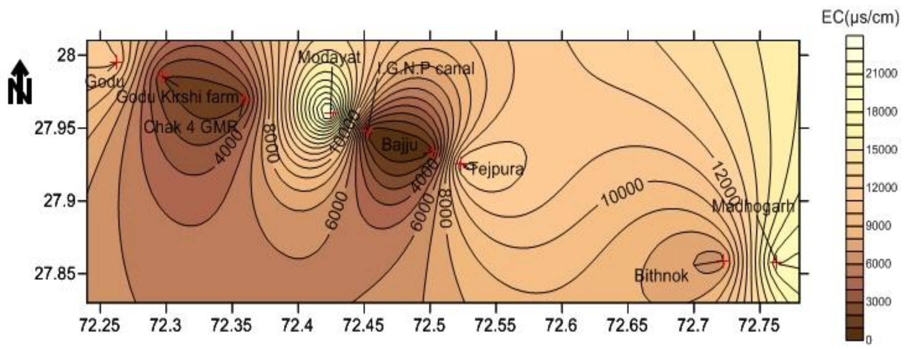

Fig. 5. Electrical Conductivity (EC) distribution in Kolayat area, Distt. Bikaner

The EC of the canal is 302 µS/cm whereas the EC of the groundwater varies from 563 µS/cm to 23600 µS/cm. The EC of groundwater along the canal varies from 563 µS/cm (Bajju) to 1916 µS/cm except Modayat. The EC plot of the study area is shown in Fig. 5. Water quality analysis confirms the same results as interpreted from groundwater contours.

The analyzed water quality parameters are given in Table 1. The constituents of water quality parameters analyzed include: pH, EC, total dissolved solids (TDS), hardness, calcium, magnesium, sodium, potassium, alkalinity, bi-carbonate, nitrate, sulphate, chloride, and fluoride. The results of the analyzed water quality parameters at different locations are compared with the permissible drinking water quality norms (IS: 10500-2012). A perusal of the data given in Table 1 reveals that of most of the locations EC values are very high except Chak 4 GMR, Godu Krishi farm and Bajju which indicates that recharge from the canal is reaching to these places. Modayat, locate close to the main canal is having anomalously high EC, this may be due to the gypsum bed. The ground water in the area has high calcium, magnesium, sodium, potassium, chloride, sulphate, they range upto 634, 787, 5890, 1015, 7908, 2650 mg/L respectively. Further, fluoride in the areas around Chak 4 GMR (3.8 mg/L), Bajju (1.93 mg/L), Godu Krishi farm (4.12 mg/L), Godu village (1.93 mg/L) exceeds the permissible limit for drinking purpose.

Table 1: Results of water quality constituents

Parameters	Sampling Locations									Permissible limit(IS: 10500:2012)
	I.G.N.P Canal	Modayat	Chak 4 GMR	Godu Kirshi farm	Godu Village	Bajju	Tejpura	Bithnok	Madhogarh	
pH	7.22	7.15	7.65	8.76	7.32	8.77	7.38	7.77	8.95	6.5-8.5
EC (µS/cm)	302	23600	1551	1916	11270	563	13400	6340	19070	-
TDS (mg/L)	193	15104	992	1226	7212	360	8576	4057	12204	2000
Hardness(mg/L)	112	1746	120	20	1756	116	3700	1184	1700	600
Ca^{++} (mg/L)	30	633	30	5	629	30	184	282	281	200
Mg^{++}(mg/L)	9	40	11	2	45	10	787	116	242	100
Na^{+} (mg/L)	20	5890	261	261	1250	52	640	750	4940	-
K^{+} (mg/L)	3.5	35	2.4	1.75	1015	18	190	194	90	-
Alkalinity(mg/L)	110	326	444	434	290	54	1100	576	74	600
HCO_3^- (mg/L)	134	397	541	529	353	66	1342	702	90	-
NO_3^- (mg/L)	4	1.4	12	22	20	19	25	21	3	45
SO_4^{--} (mg/L)	100	2650	134	155	2650	120	700	285	1400	400
Chloride(mg/L)	54	7908	300	228	2568	70	2500	1538	6538	1000
Fluoride(mg/L)	0.2	1.38	3.8	4.12	1.93	1.58	-	0.72	1.09	1.5

5 CONCLUSIONS

Impact of recharge from I.G.N.P canal on groundwater quality has been studied in Kolayat block. The area traversing IGNP canal (extends in NE-SW direction and flows towards SW) passes through Kolayat (Bajju field station) is studied to understand the characteristic of groundwater and its dynamics. The groundwater levels are measured and samples were collected from 40 Km in the eastern and 20 km in the western direction. The groundwater data analysis reveals that depth to water level varies between 10 and 55 m bgl. The water levels are shallow in western direction and upto Bajju in eastern direction from the canal. The water level become deeper as we move towards eastern direction from Bajju. The groundwater dynamics suggest that the canal is recharging towards western direction and upto Bajju in the eastern direction. Physiochemical water quality analysis of canal and groundwater samples confirms the same result. The EC of the canal is 302 µS/cm where as the EC of groundwater varies from 563 µS/cm to 23600 µS/cm. The groundwater in general is not suitable for drinking purposes as salinity and fluoride exceeds the limit from Indian standards drinking water.

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Domestic Wastewater Treatment Using Tanfloc: A Tannin Based Coagulant

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Abstract: Fresh water resources in most areas of world are shrinking at an alarming rate and may not meet the ever increasing demands for domestic, agriculture and industry in future. Moreover, estimates reveal an annual production of ~30 MT of wastewater in the World. In India, estimated sewage water generation from Class-I and Class-II cities is 38255 MLD, out of which only 11787 MLD is being treated. The untreated wastewater enters in groundwater, rivers, and other water bodies thereby making it unfit for human consumption. The projected wastewater generation in India will be 122000 MLD by 2050, which necessitates strengthening of existing treatment plants and investment in new treatment plants for safeguarding fresh water resources and human health. Pre-treatment is an integral part of any wastewater treatment scheme and results in appreciable reduction in capital as well as operating cost associated with downstream units due to reduction in organic load. A tannin based natural flocculent (Tanfloc) along with ferric chloride was used for pre-treatment of domestic wastewater using jar-test. It was able to achieve reduction in turbidity, COD, and BOD up to 95%, 69%, and 60% respectively. The optimum dosage for treatment of municipal wastewater under investigation was 10 ppm ferric chloride with 15 ppm Tanfloc.

Keywords: Wastewater, Coagulant, Tannin, Organics

1 INTRODUCTION

Ineffective sanitation infrastructures facilitate every year 2.2 millions of deaths by diarrhoea, mainly among child under 3 years old, 6 million people blind from trachoma and 200 million people infected with schistosomiases [1]. Obviously, most of them in developing countries, so appropriate technologies referring urban wastewater may be investigated in order to broaden the variety of technical possibilities of treatment. In this sense, many types of water treatment are being used. Their differences lay on economical and technical features. Several previous papers have pointed out the importance of urban wastewater management [2,3]. This type of waste has been a target for social studies, as it involves several aspects that have to do with social structure and community organization [4,5]. According to this dimension, it is very important to consider wastewater management as a social change factor in developing countries, as the relationship between wastewater treatment and production, on one hand, and human developing process, on the other, is rather known. Researching on other procedures of water treatment has been the scope of this work. For several years, investigators are concerned towards working on an alternative process for water treatment, mostly bearing in mind concepts such as sustainability, affordability and social feasibility. In this sense, natural coagulants/flocculants are wide-spread, easy-handling resources that are not difficult to work with by non-qualified personnel. There are some examples of this agent, such as Moringa oleifera [6] or Opuntia ficus [7]. Tannins may be a new source for coagulant and flocculent agents. The main aim of the present investigation is to characterize the coagulant and flocculent activity of this new tannin-based product (Tanfloc) as a municipal wastewater treatment. TANFLOC flocculent product is a trademark that belongs to TANAC (Brazil). It is a tannin-based product, which is modified by a physicochemical process, and has a high flocculent power. It is obtained from an Acacia mearnsii bark. This tree is very common in Brazil and it has a high concentration of tannins. According to TANAC specification, TANFLOC is vegetal water extract tannin, mainly constituted of flavonoid structures with an average molecular weight of 1.7 kDa. More groups such as hydrocolloid gums and other soluble salts are included in the TANFLOC structure. Chemical modification includes quaternary nitrogen that gives TANFLOC cationic character.

2 MATERIALS AND METHODS

2.1 CHEMICALS

TANFLOC has been kindly supplied by TANAC (Brazil). The reagents used throughout the investigations were A.R. grade and procured from Merck/Qualigens chemicals and all the solutions were prepared with deionized water. All the glassware used during the experiment were thoroughly cleaned by soaking in chromic acid solution and finally rinsed with de-ionized water several times prior to use.

2.2 DOEMESTIC WATEWATER

The sewage/domestic wastewater was collected from Khanjarpur drain (Roorkee), which receives domestic effluent from IIT Roorkee and nearby habitation. Samples were collected immediately before conducting the experiments in order to avoid any change in the actual composition of sample.

2.3 JAR TEST PROCEDURE

Jar-test was selected as the standard treatment in order to study coagulation process. The procedure was: 0.5 L of sewage was put into a beaker. Certain dose of coagulant/ flocculent was added, and beaker was put into a magnetic stirrer (Remi Make). The solution was stirred at 500 rpm for 2 minutes after addition of chemicals followed by slow stirring at 150 rpm for 20 minutes in order to mimic the process taking place in solids contact clarifier. Treated water samples were obtained from the centre of beaker, 3 cm from the surface.

2.4 ANALYTICAL METHODS

All analytical measures were made according to the Standard Methods for the Examination of Water and Wastewater [8].

3 RESULTS AND DISCUSSION

3.1 EFFECT OF TANFLOC DOSAGE

As a first approach, different dosage of Tanfloc flocculent (2-20 ppm) was added to sewage sample to understand the efficacy of the chemical towards reduction of pollutants. Turbidity was reduced by 85.6% with 20 ppm Tanfloc dosage. The optimum dosage for COD reduction was found to be 10 ppm with 62.8% reduction. Higher does not yield any further reduction. Maximum BOD reduction (57.7%) was observed with 20 ppm dosage (Figure 1).

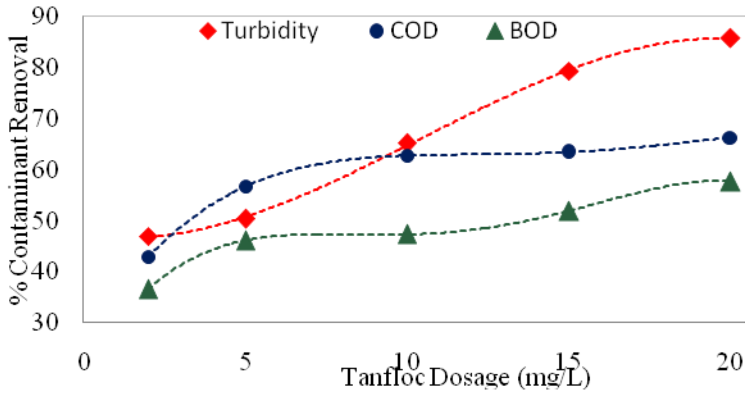

Fig. 1: Effect of Tanfloc Doses on Turbidity, COD, and BOD Reduction

3.2 SYNERGISTIC OF FERRIC CHOLRIDE AND TANFLOC DOSAGE

Tanfloc is a flocculent and hence, its efficiency can be improved by dosage of coagulant. To understand the effect of coagulant, Tanfloc was dosed in varying dosages (2-20 ppm) along with 10 ppm ferric chloride. Ferric chloride was selected based on pH of sewage, which is most suited for iron based coagulants. Prominent reduction in the contaminants was observed with the combined effect of ferric chloride (coagulant) and Tanfloc (flocculent). Maximum reduction in turbidity (96.9 %) and COD (81.4 %) was achieved with 15 ppm Tanfloc dosage whereas maximum reduction in BOD (80.7 %) was achieved with Tanfloc dose of 10 mg/L (Figure 2). So, in this case the optimum dosage of Tanfloc was 15 ppm. Dosing Tanfloc, above 15 ppm resulted in reduced contaminant reduction efficiency. This may be due to formation of daughter aggregates as a result of addition of charge to the neutralized aggregates.

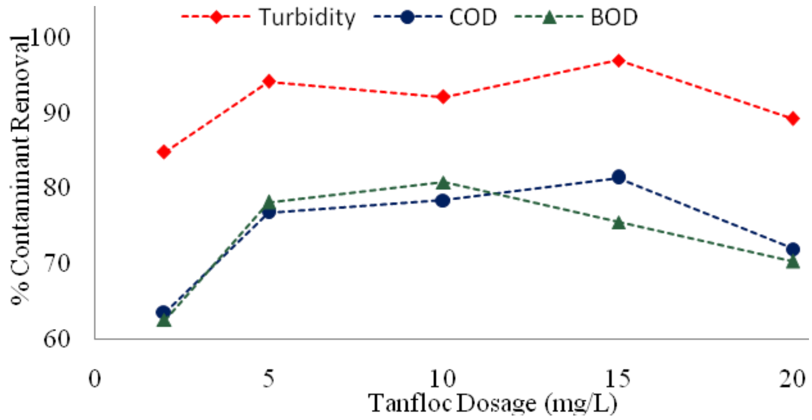

Fig. 2: Effect of Tanfloc and Ferric Chloride Dosing on Turbidity, COD, and BOD Reduction

3.3 OPTIMIZATION OF COAGULANT (FERRIC CHLORIDE) DOSAGE

For achieving the optimum dosage of ferric chloride, Tanfloc dosage was kept constant (15 ppm) and ferric chloride dosage varied (5-20 ppm). Percentage reduction of contaminates is shown in figure 3.

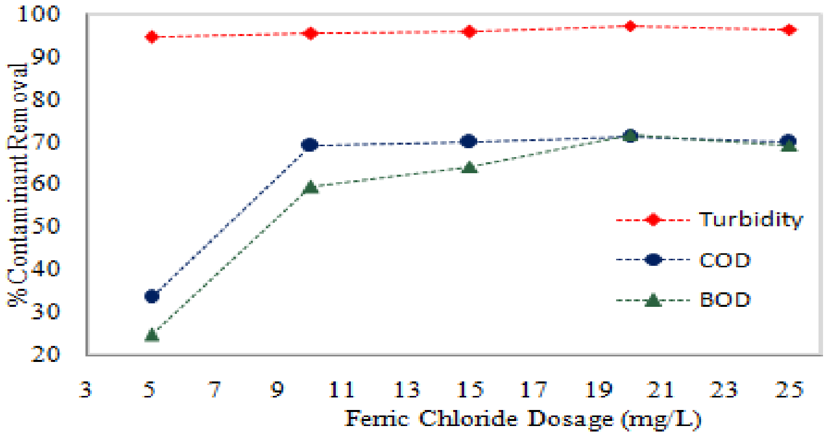

Fig. 3 : Effect of Ferric Chloride Doses on Turbidity, COD, and BOD Reduction

It can be concluded from this experiment that with 15 ppm Tanfloc, 5 ppm ferric chloride is sufficient to produce optimized result in terms of turbidity. For maximum reduction in COD and BOD, the dosage of ferric chloride is 10 ppm and 20 ppm respectively. Considering all the three parameters, the optimum dosage of ferric chloride is 10 ppm along with 15 ppm Tanfloc. This also result in appreciable reduction in sludge volume.

4 CONCLUSIONS

The conclusions that may be drawn from the present investigation are-

- The tannin based flocculant (Tanfloc) can be used for treating municipal wastewater (sewage).
- Efficiency of Tanfloc increases manifold with coagulant such as ferric chloride in for removing turbidity, COD, and BOD.
- Up to 95 % turbidity, 69 % COD, and 60 % BOD is removed with Tanfloc treatment along with ferric chloride.
- The optimum dosage for the sewage under investigation was 10 ppm ferric chloride with 15 ppm Tanfloc.

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