ASSESSMENT OF TEXTILE EFFLUENT DISCHAGE ON WATER QUALITY IN PALI DISTRICT

Dr.vinita koka, Associate professor, Textile Dyeing and Printing

Govt. Bangur College Pali,(Rajasthan)

JNVU University, Jodhpur

ABSTRACT

Environmental pollution is one of the severe problems due to rapid industrialization. The phenomenon is very common in textile industries. The effluent discharged by these industries lead to serious pollution of surface water and ground water. Pali is best known for dyeing and printing of cotton and synthetic fabrics. Pollution is the main accuse in the textile processing units. The effluents discharged from these units causes environmental pollution. Textile effluents discharged from various textile processing units of Pali, flow about 55 Kilometer downstream, making the ground water in several riverbank villages unfit for drinking and irrigation and also causes adverse effect on crops productivity and health of people residing in those areas. Before disposal they need to be treated for certain acceptable tolerance limits since pollution control laws are strictly followed all over the world and captured worldwide attention. The use of toxic chemicals in these units cause threat to the manpower employed in such units in a way directly resulting in occupational health hazards. Further to be in tune with the government restrictions to be connected to CETP, majority of textile processing houses/units of Pali district are now adjoined to CETP. Inspite of the installation of CETP, the Bandi River still have enormous water pollution adversely affecting the purity of drinking water.

The present paper is based on result of one aspect of research work carried out to study the impact of textile effluent on environment in terms of water contamination in selected areas.

Key words: Water, Pollution, Pali , Textile, Processing, Units, Effluents

INTRODUCTION

Environmental pollution is one of the severe problem due to rapid industrialization. The phenomenon is very common in textile industries. The effluent discharged by these industries lead to serious pollution of surface water and ground water. Pali is best known for dyeing and printing of cotton and synthetic fabrics. Pollution is the main accuse in the textile processing units. The effluents discharged from these units causes environmental pollution. Textile effluents discharged from various textile processing units of Pali, flow about 55 Kilometer downstream, making the ground water in several riverbank villages unfit for drinking and irrigation and also causes adverse effect on crops productivity and health of people residing in those areas. Before disposal they need to be treated for certain acceptable tolerance limits since pollution control laws are strictly followed all over the world and captured worldwide attention. The use of toxic chemicals in these units cause threat to the manpower employed in such units in a way directly resulting in occupational health hazards. Further to be in tune with the government restrictions to be connected to CETP, majority of textile processing houses/units of Pali district are now adjoined to CETP. Inspite of the installation of CETP, the Bandi River still have enormous water pollution adversely affecting the purity of drinking water. The present paper is based on result of one aspect of research work carried out to study the profile of textile processing units of Pali district and to assess the impact of textile effluents discharge on environment in terms of water contamination in selected areas.

Methods of investigation:

The present study was conducted in Pali district of Rajasthan as it has the largest number of textile processing units in the Bandi basin. These textile industries provide substantial contribution to the economy in the form of income and employment generation. The key issue was that these industries are discharging effluents into the river Bandi, thus severely contaminating both the river as well as groundwater in several riverbank villages making it unfit for drinking and irrigation purpose. The area of present investigation was kept within the periphery of 55 kilometer in and around Bandi River for assessment of water contamination.

Locale of the study:

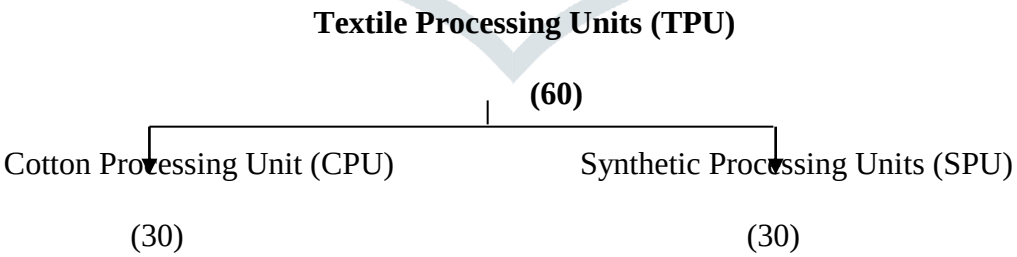
A list of textile processing units was procured from District Industries Centre (DIC) Pali, which was registered since last 20 years. Out of these, 30 units each among cotton textile processing and synthetic textile processing units connected with Common Effluent Treatment Plant was purposively identified and selected, whose effluent was directly or indirectly being discharged in Bandi river in order to assess the impact of effluent on environment in terms of water contamination after being treated with CETP.

Selection of sample

The sample selection was done as per the objectives of the study.

Selection of textile processing units (TPU)

A list of textile processing units was procured from District Industries Centre (DIC) Pali, which was registered since last 20 years. Out of these, 30 units each among cotton textile processing and synthetic textile processing units connected with Common Effluent Treatment Plant was purposively identified and selected, whose effluent was directly or indirectly being discharged in Bandi river in order to assess the impact of effluent on environment in terms of soil and water contamination after being treated with CETP. The respective heads of the selected TPU were interviewed to study the profile of the textile units.



Selection of Common Effluent Treatment Plant (CETP)

In Pali district, four CETP units have been installed to treat the enormous textile effluents discharge from various cotton and synthetic textile processing units. CETP unit-I and II are situated at Mandia road, industrial area and unit-III and IV are situated at punayata road, industrial area. The respective textile processing units of these areas are connected with these plants. Due to heavy concentration of TPU (approximately more than 500 units) in Mandia road industrial area, the researcher purposively selected CETP unit-I and II for the present investigation.

Water samples

In order to assess the impact of textile effluents on environment in terms of water contamination, the samples of water were collected from–

- Nearby villages situated within the periphery of 55 kilometer of Bandi River.
- Those villages having a population of at least 1000 houses.
- Those villages, where land is being used for crop cultivation and ground water for irrigation and drinking purpose.

For this purpose, a total number of eight villages adjoining to Bandi River fulfilling the above criterion were be selected purposively.

The researcher in total collected 28 water samples on random basis from the selected eight villages i.e. Jawadia, Kerala, Gadwada, Sukarlai, Jetpur, Dholaria, Nehda, Phankaria and Nehda dam of Pali district adjoining the Bandi river, from open wells, hand pumps and river. In some places hand pumps were not in function or unavailable so water samples were collected only from open well and river. The water samples were collected during the daytime. They were collected in one liter plastic bottles. Before sampling, the plastic bottles were cleaned thoroughly to remove all surface contamination, rinsed with double distilled water and dried. The collected samples were properly brought to the laboratory without adding any preservative. Suspended matter if any, in the samples were removed by filtering through Whatmann filter no. 41. Then it is properly labeled and stored in the refrigerator till the analysis was over.

Analysis of physio-chemical characteristics of water samples

The quality of water samples collected from different selected villages were analyzed on different parameters such as colour, odour, pH, Electrical Conductivity (EC), Total Dissolved Solids(TDS), Dissolved Oxygen (DO), Total hardness, Chloride, Nitrate, Sulphate and under Heavy metals – lead (Pb), Copper (Cu), Arsenic (As), Chromium (Cr), Zinc (Zn), Nickel (Ni), Cadmium (Cd), and Iron (Fe). All the parameters mentioned above for analysis of quality of water samples were assessed by using standard test methods.

Data collection

Personal interview method was used for collecting the data regarding profile opf Textile processing units of Pali district. Before conducting interview the purpose of study was explained to the respondents. Probing was done to get clear and complete information. The interview was conducted in Hindi or when needed in local language. This helped them to understand the questions more clearly

Analysis of data

After collecting the data, the same was coded, according to preplanned format. It become necessary to analysis it in order to arrive at some conclusions. The data were statistically analyzed through frequencies and percentages.

Compare the calculated F-ratio with that given in the F-table at df between the classes and at df within the classes at desired level of significance. If calculated value is greater than tabulated value, null hypothesis (H_0) is rejected and alternative hypothesis of significant difference between means is accepted.

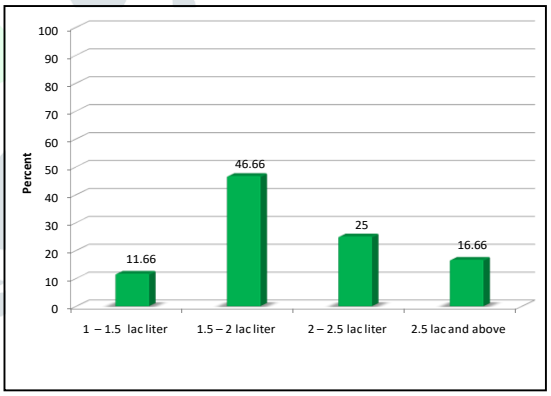
Major findings:

Profile of Textile Processing Units

At present in Pali, 867 textiles industrial units are in operation at small scale due to lack of capital. There are about four RIICO developed industrial area in the city. Mandia Road industrial area- phase III alone has about 525 small scale textile units, which is 60.55 percent of the total dyeing and printing industries. Majority of textile processing units were selected from Mandia Road Industrial area due to higher concentration in that area.It was found that majority (66.66%) of textile processing units were established between year 1990-2000 followed by 25 percent sample units in year 1980-1990. Majority (35%) of textile processing units covered the area between 2000-3000 square feet while 26 percent textile processing units were spread between 3000-4000 square feet area. Total capital investment was found between 3 to 4 crore by 36.66 percent followed 30 percent between 2 to 3 crore. Data on production per month was found in between 10 to 15 lac meters; that means average production of approximately 300 'than'for dyeing and 150 'than for printing per day. One 'than' is equal to near about 130 meters. 40 percent of responding units had yearly turnover between 20-30 crore, 31.66 percent between 30-40 crore and only 10 percent had 40-50 crore. All the respondents used synthetic dyes for dyeing and printing. Very few respondents (16.66%) also used eco-friendly dyes, for fabric coloration as per the export order procured. Mainly two types of fabrics were used for dyeing and printing i.e. cotton and polyester. For cotton, mainly Reactive, Ramazol, High Exhaustive dyes, Azoic dyes, vat dyes and sulphur dyes was used. Disperse dye was applied on most of the synthetic fabric. For polyester, it is only for colouring. Procion and pigment dyes were used for printing of cotton fabric and disperse dyes for polyester printing.

Requirement of water

Adequate water supply is the biggest problem in textile dyeing and printing units of Pali. The reservoirs of Hemavas and wells along the bank of Bandi River supply the requirement of water to the inhabitants and also to the dyeing printing units. Water requirement per day in textile processing units depends on the size of the unit and production capacity. Approximately 5 to 6 liter of water on an average is needed up to the final product of one meter cloth. Majority of the units (46.66%) required 1.5 lac to 2 lac liter water per day for textile processing followed by 25 units whose water requirement is 2 to 2.5 lac liter per day.



Wastewater discharged

The waste water generation by the dyeing and printing units is due to various activities preformed on grey clothes to shape the final products. All the respondents reported that 60 to 70 percent of total water consumed in textile processing is being discharged as 'waste water' after final finishing of the products.

No effluent treatment

Majority of the respondents were agreed that textile processing units created hazardous effect on the environment through water pollution (86.66%). Majority of units had no provision of primary treatment being of small scale industry. It was evident that respondents did not reuse the waste water; they directly discharged it in the drains which were connected to common effluent treatment plant. Very few respondents (23.33%) used to give primary treatment to the waste water to maintain pH. Hence most of

contaminated water used to deposit in the bed of Bandi River flowing adjacent to town thus causing water, air and soil pollution

Association with Common Effluent Treatment Plant (CETP)

Although each of the textile processing unit in the study area was connected with the CETP, but very few respondents (25%) were satisfied with the functioning of CETP. Majority of the respondents (86.66%) were not aware about the clean technologies and about eco friendly chemicals and processes.

Physiochemical analysis of ground water samples

The quality of water is usually determined by its physiochemical characteristics. The experimental design for the present scientific investigation involved the complete physio-chemical analysis of water samples collected from open well, hand pump, river and dam from eight selected villages adjoining the Bandi River. The water samples of these point sources was tested for different parameters like colour, odour, pH, EC, TDS, DO, total hardness, chloride, nitrate and sulphate. The values are compared with permissible limit of drinking water (BIS, 1983; IS 10500-1983).

Table 1: Characteristic of Drinking Water (BIS, 1983; IS 10500-1983)

S.No.	Parameters/ Characteristics	Desirable Limit	Maximum Permissible Limit
1.	pH value	6.5-8.5	No relaxation
2.	Total dissolved solids	500	1500
3.	Total hardness	300	600
4.	Dissolved oxygen	10	3
5.	Chlorides	250	1000
6.	Nitrate	45	No relaxation
7.	Sulphate	200	400

Table 2 indicates list of ground water samples collected from right selected villages adjoining the Bandi river by different sources like open well, hand pump and river.

Table 2: List of ground water sample sites for physicochemical analysis

GW Sample	Site	Source
S_1, S_2 S_3, S_4, S_5,S_6, S_7, S_8	Jawadia, Kerala Gadwada Sukarlai Jetpur, Dholaria Nehda, Phankaria	Open well
S_9, S_{10}, S_{11}, S_{12}	Jawadia, Kerala Gadwada, Dholaria	Hand pump
S_{13},S_{14}, S_{15}, S_{16}, S_{17}, S_{18}, S_{19}	Jawadia, Kerala, Gadwada, Sukarlai Jetpur, Dholaria, Nehda,	River
S_{20}	Nehda Dam	Dam

Further the table-3 indicates the mean values of the different water quality parameters and statistical analysis of results are depicted in table 4-11.

Table 3: Mean Values of different water quality parameters

Site	pH	Electrical Conductivity	Total Dissolved Solids	Dissolved Oxygen	Total hardness	Chloride	Nitrate	Sulphate
S1	8.64	10.61	3338.00	4.57	459.33	322.00	37.33	224.00
S2	8.16	10.08	3014.00	4.78	474.33	261.33	40.33	247.33
S3	8.41	8.49	3248.67	5.07	423.33	322.67	51.33	211.33
S4	8.67	9.23	3572.67	4.19	484.00	309.67	41.33	323.33
S5	7.72	10.21	3705.67	6.31	420.67	345.33	49.33	346.00
S6	7.51	11.23	3579.33	5.07	414.00	360.67	52.00	310.67
S7	8.50	10.52	3099.67	4.61	554.33	419.33	59.33	386.00
S8	8.21	8.23	3299.67	4.11	484.67	344.67	47.67	320.33
S9	7.55	6.23	2280.33	3.91	335.67	243.33	31.67	228.33
S10	7.86	5.43	1985.67	3.51	430.33	243.33	27.33	228.33
S11	7.97	7.23	1941.33	4.58	377.33	254.67	36.67	174.67
S12	8.03	8.25	1137.33	4.59	319.67	215.33	24.67	198.67
S13	8.41	12.32	5229.33	3.19	579.33	341.33	63.33	364.67
S14	8.65	12.59	4849.33	2.79	657.33	360.67	53.67	376.00
S15	8.66	10.21	5239.33	2.49	620.67	340.33	47.33	319.33
S16	8.44	11.23	5099.67	3.10	685.33	379.33	51.33	340.67
S17	8.54	10.65	6720.67	2.61	624.67	357.33	58.67	419.33
S18	8.51	10.88	6240.67	2.49	660.67	374.67	71.33	429.33
S19	8.68	9.45	5620.67	2.29	664.33	379.33	70.67	413.33
S20	8.91	12.23	7099.33	2.19	679.33	387.33	73.33	429.33

Colour :

Colour of water is very important factor for their acceptance. coloured water is not authentically accepted to general public. Colour is removed to make water suitable for general and industrial use. In the present investigation, river water and Dam water samples were found greenish in colour, while Hand pump water sample was colourless. Sample S1, S3, S5 and S7 possessed pale yellow to greenish colour this may be due to discharge of textile effluents discharged from various textile processing units.

Odour : Odour is a very important physical character of water which indicates the organic load of any water bodies. Odour cause psychological stress rather than harm to the human body. The findings of present investigation revealed that all the samples collected from Bandi River and nearby dam had unpleasant odour, due to the decomposition of organic matters and chemicals present in them. Hand pump water samples were found odourless. Some of the open wells which contained slightly coloured water also had odour of chemicals.

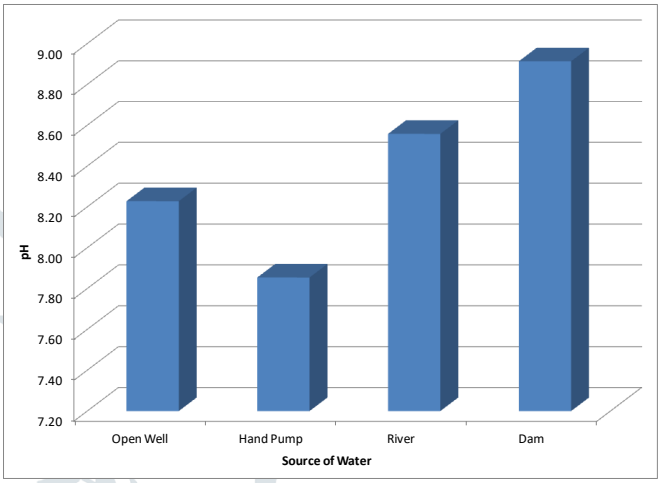
pH – The pH is defined as the negative logritherm of the hydrogen ion (H^+) concentration in the solution. pH is important chemical factor which shows the acidic and basic characteristic of water. The pH value of water samples of open well (7.51-8.64), hand pump (7.55-8.03) and river (8.41-8.97) suggested the alkaline nature of ground water in the study area.

Statistical analysis of physio-chemical water quality parameters from different sources

Table 4: pH

Source	N	Mean	SD	F	df	Result
Open Well	24	8.23	0.40	21.38	3, 56	***
Hand Pump	12	7.85	0.19			
River	21	8.56	0.11			
Dam	3	8.91	0.01			

For the statistical analysis one way ANOVA was conducted to the see the difference in pH of all the water sources. The results of statistical analysis are shown in table. From the table-4, it is cleared that highly significant difference was found in pH value of different sources of water ($F = 21.38$, df – 3,56 & $P < 0.001$), The pH value was found to be lowest for water samples of hand pump and highest for Dam water followed by river and open well. However, pH value of all the water samples falls within the permissible limit except Nehda Dam. It means the ground water samples of the study area were found alkaline in nature.



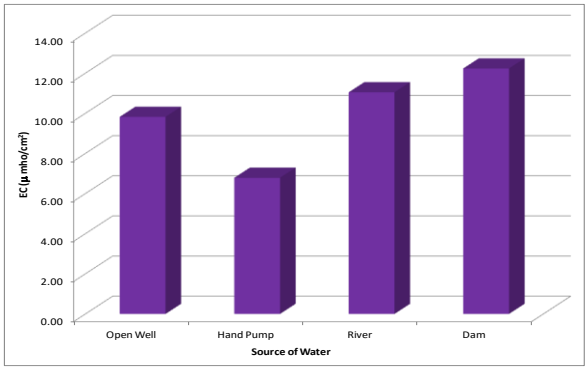
Similar results have been observed by Geetha et. al. (2008) who found alkaline pH (6.96 to 8.5) at the time of assessment of ground water contamination and effect of textile effluent on Noyyal River Basin in and around Tiruppur.

Electrical conductivity: The conductivity of water is due to the presence of various salts in water in ions (cations & anions) forms. Conductivity of water increases with increases in pollution and it directly proportional to the amount of dissolved salts. Electrical conductivity in water samples were observed in range of open well (8.23-11.23), hand pump (5.43-8.25), river (9.45-12.59) and Dam (12.23) with a mean value of 9.8umho/cm^2, 6.79umho/cm^2, 11.05umho/cm^{2}and 12.23umho/cm^2 respectively.

Table 5 : Electrical Conductivity (EC)

Source	N	Mean	SD	F	df	Result
Open Well	24	9.82	1.02	49.68	3, 56	***
Hand Pump	12	6.79	1.11			
River	21	11.05	1.06			
Dam	3	12.23	0.01			

For the statistical analysis, one way ANOVA was conducted to see the difference in electrical conductivity of all water sources. The results of statistical analysis are shown in table-5. From the table it is clear that t highly significant difference was found in EC values of different water sources. . Ec values were found higher than the permissible limit (0-1 umho/cm^2). Hence it was found highly unsuitable and injurious for proper growth of plants and crops due to chemicals, salts and dissolved solids. Higher EC



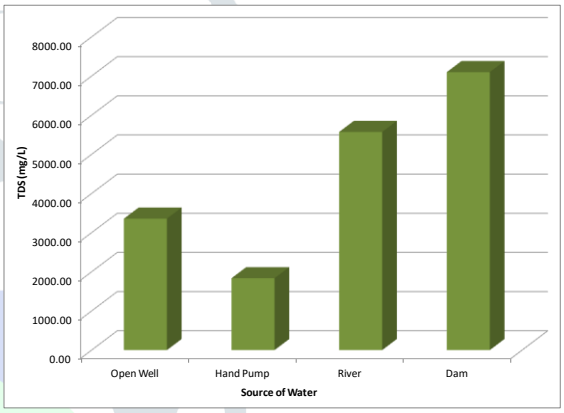
indicates the presence of high amount of dissolved inorganic substances in ionized form (Murhekar, 2011).

Total Dissolved Solids (TDS): Total dissolved solids (TDS) is the measure of total inorganic salts and other substances viz ; Sulphates ,Phosphates, carbonates, bicarbonates, chlorides, nitrates etc. in water. Water with high dissolved solids is of inferior potability and may include an unfavorable physiological response in the body of consumer (Bhanja and Patra, 2000).Permissible limit of TDS is 500-1500mg/l. A high content of dissolved solids elevates the density of water, reduces utility of water for drinking irrigation and industrial purpose.

Table 6: Total Dissolved Solids (TDS)

Source	N	Mean	SD	F	df	Result
Open Well	24	3357.21	233.16	235.46	3, 56	***
Hand Pump	12	1836.17	442.84			
River	21	5571.38	641.37			
Dam	3	7099.33	1.15			

The same trend as that of electrical conductance was recorded for TDS. TDS was observed to be very high in all the water samples. TDS value of open well ranged between 3014 -3579.33 mg/l with the mean value of 3357.21 mg/l. TDS value of hand pump ranged from 1137.33-2280.33 mg/l with the mean value of 1836.17mg/l. and mean value of River and Dam were 5571.38 and 7099.33mg/l respectively. It was very high from the permissible limit.



For the statistical analysis one way ANOVA was conducted to see the difference in TDS value of different water sources. The results of analysis shown in table no.6. From the table it is clear that highly significant difference was found in TDS value of all sources of water samples. ($F=235.46$, $df = 3,56$ & $p < 0.001$).

The results of this experiment exhibit higher values of TDS in water samples of Nehda dam and river source which may be due to direct discharge of textile effluents from textile processing units in river reaching to Nehda dam. High values of TDS in groundwater are generally not harmful to human beings but higher concentration of these may affect persons, who are suffering from kidney and heart diseases (Gupta et. al. 2004). Water containing high solids may cause laxative or constipation effects (Kumaraswamy, 1999).

Dissolved oxygen (DO): Oxygen dissolved in water, often referred to as dissolved oxygen is one of the most important water quality parameters. The dissolved oxygen level in natural and waste water depends on the physical, chemical and biological activities in water bodies. According to the study, values of dissolved oxygen was found satisfactory in open well (6.31 to 4.11 mg/e) and hand pump (4.59 to 3.51 mg/l) with mean value 4.84 mg/l and 4.15 mg/l respectively. Dissolve oxygen of river and dam was found very low with mean value of 2.71 mg/l and 2.19 mg/l respectively.

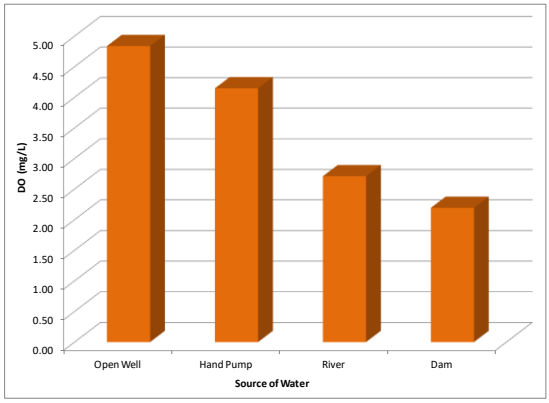


Table 7: Dissolved Oxygen (DO)

Source	N	Mean	SD	F	df	Result
Open Well	24	4.84	0.66	76.61	3, 56	***
Hand Pump	12	4.15	0.48			
River	21	2.71	0.32			
Dam	3	2.19	0.01			

For the statistical analysis one way ANOVA was conducted to see the difference in DO value in all water sources. The results of statistical analysis are shown in table no.7. From the table-41 it is clear that a high significant difference was found in all water samples. (F=76.61, df 3,56 & p > 0.001).

Kolhe and Panwar (2011) also reported that dissolved oxygen of untreated effluents was totally nill which may be due to oil and grease in effluent from milk which inhibits or prevents the enhance of atmospheric oxygen into effluent and amount of dissolve oxygen present in treated effluent was 3.5 mg/l. Ranu (2001) observed the range of 1.8 to 9.1 mg/l of dissolved oxygen in water bodies of Bandi river system.

Total hardness : Hardness of water mainly due to cations of calcium and magnesium and anions like carbonate, bicarbonate and sulphates, as calcuium and magnesium make bonds with carbonates and bicarbonates. Alkalinity and water hardness closely interrelated .Water with hardness up to 75mg/l are termed soft water while to water with hardness of more than 300 mg/l are considered hard.

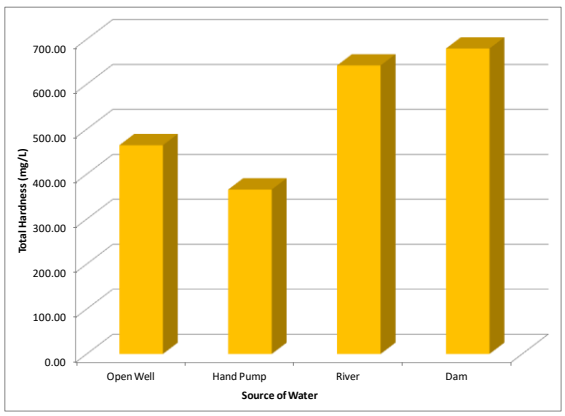
During the investigations, high values of hardness were recorded in all the water sources. Nehda dam recorded the highest total hardness value followed by river (ranging 579.33 to 685.33 mg/l) with mean value 679.33 and 641.76 mg/l respectively.

Table-8 indicates that there was highly significant difference in all the water sources collected from selected village adjoining the Bandi river (F=154.23, df = 3,56 & P < 0.001).

Table 8: Total Hardness

Source	N	Mean	SD	F	df	Result
Open Well	24	464.33	44.46	154.23	3, 56	***
Hand Pump	12	365.75	44.73			
River	21	641.76	33.87			
Dam	3	679.33	1.15			

The value of total hardness was found high in river water and Dam than the permissible limit, it clearly indicates that the textile effluent has affected the ground water. Though it affects ground water, it has no adverse effect on human health. In most of the samples, total hardness value exceeds the tolerance limit; this may be due to industrial discharge of the effluents on the land.



The findings are in concurrence with Pandey and Sharma (1998) who found that the hardness value fluctuated between 129 to 1465 mg/l in polluted Ramganga River at Moradabad. Jacob et al. (1999) observed hardness of water

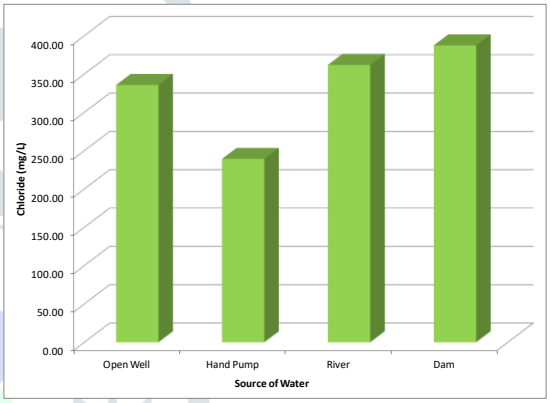
vary from114 to 434 mg/l in river Noyyal of Tripura. Ranu (2001) observed the minimum of 137.5 mg/l and maximum of 800.00 mg/l values of hardness in water bodies of Bandi river system.

Choride : Chloride content in water also indicates the level of pollution. Domestic and industrial pollutants tend to increase chloride content of receiving water bodies (Palaria and Rana, 1985), water that contain less than 150 mg/l of chloride is satisfactory for most purpose. Chloride content of more than 250 mg/l generally objectionable and makes water salty in taste.

Table 9: Chloride

Source	N	Mean	SD	F	df	Result
Open Well	24	335.71	43.29	48.14	3, 56	***
Hand Pump	12	239.17	15.19			
River	21	361.86	15.90			
Dam	3	387.33	1.15			

Maximum chloride content was found at Nehda dam (387.33 mg/l.)In the river water samples, the value of chloride ranged from 26.33 to 419.33 mg/l with mean values 361.86 mg/l. The chloride content in hand pump samples ranged between 215.33 to 254.67mg/l with mean value of 239.17. It was found within the permissible limit.



The results of statistical analysis are shown in table -9 From the table it is clear that high significant difference was found in chloride values of all the sample of different sources. ($F=48.14$, $df = 3,56$ & $p < 0.001$)

The reasons behind high chloride value may be due to the continuous usage of chloride salts in the textile processing industries preferably in dyeing and bleaching. Chloride content of river Ramganga fluctuated between 10 - 42 mg/l (Pandey and Sharma, 1998) who studied on pollution of River Noyyal, revealed that the chloride values ranged between 1218 to 4490 mg/l (Jacob et. al., 1999).

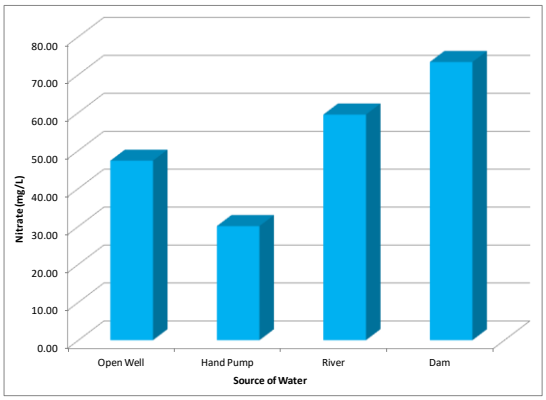
Nitrate : Nitrate is highest oxidisable form of nitrogen and occurs in trace quantity in surface water. The main contribution for nitrate in ground water is the nitrogenous fertilizers of both animal and chemical origin and also sewage and industrial waste. If the concentration of nitrate is greater than 45 mg/l, the water is undesirable for domestic purpose because of the possible toxic effect.

The nitrate value was found high in river water (37.33 to 59.33 mg/l) open wells (47.33 to 71.33) and dam water except hand pumps in which the values ranged between 24.67 to 36.67 mg/l which was found within the permissible limit.

Table 10 : Nitrate

Source	N	Mean	SD	F	df	Result
Open Well	24	47.33	7.01	52.66	3, 56	***
Hand Pump	12	30.08	4.80			
River	21	59.48	8.95			
Dam	3	73.33	1.15			

For the statistical analysis, one way ANOVA was conducted to see the difference in nitrate value of all the sources. The results of analysis are shown in table -10. From the table it is clear that highly significant difference was found nitrate value of all the water sources. (F=52.66, df=3,56 & P Z<0.0014).



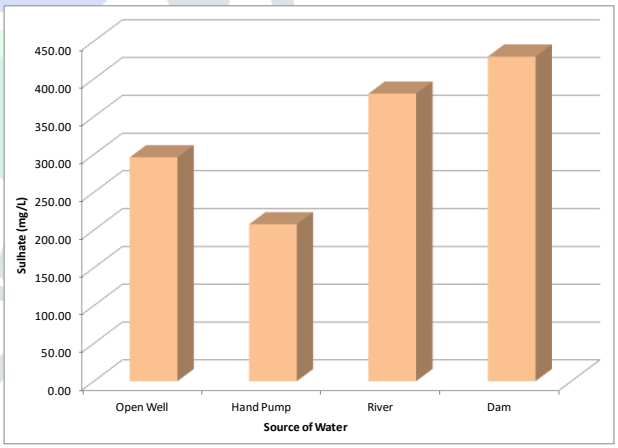
Sulphate : The sulphate ion is one of the major anion occurring in natural water. It is one of the least toxic anion. Water with about 300-400 mg/l sulphate has bitter taste and those with 1000 mg/l or more of sulphate may cause intestinal disorder. More than 250 mg/l of sulphate concentration in ground water is objectionable.

In the present investigation value of sulphate was found in the range 211.33 to 386.00 mg/l and 198.67 to 429.33 mg/l in open well and river water with a mean value of 296.13 mg/l and 380.38 mg/l respectively. The mean value of sulphate in hand pump water was found 207.50 mg/l i.e. within the permissible limit. Dam water possessed maximum value of sulphate (429.33 mg/l) which is highly toxic.

Table 11: Sulphate

Source	N	Mean	SD	F	df	Result
Open Well	24	296.13	59.22	43.49	3, 56	***
Hand Pump	12	207.50	23.50			
River	21	380.38	39.89			
Dam	3	429.33	1.15			

Table-11 shows the statistical analysis of sulphate value in all the water sources. From the table it is clear that highly significant difference was found in the sulphate values of different sources of water open well, hand pump, river and dam. (F = 43.49, df = 3, 56 & p <0.001).



The sulphate concentration in the study area did not show any remarkable deviation and were very much within the tolerance limit except Nehda dam.

The sulphate concentration were high in Domestic and industrial effluent which attributes large amount of discharge of sewage and chemicals from the urban area and industrial units (Murhekar, 2011).

On the basis of findings present investigation, obtained for various physiochemical parameters of water samples from different sources like open well, hand pump, river and dam from selected villages, it can be concluded that the underground water quality was contaminated except the hand pump water. All the water parameters like EC, TDS, Total hardness, chloride, Nitrate were crossing the permissible limit and the water was not fit for drinking and irrigation purpose. Hence the result suggested that the under ground water may be altered in future due to increase in population, urbanization and rapid industrialization of this catchment area. Therefore, there should be proper disposal of waste water, after treatment as well as recycling of waste water along with periodical monitoring of the underground water for future sustainability.

Analysis of heavy metals in ground water samples

The term 'heavy metal' refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations. Heavy or toxic metals are trace metals with a density at least five times that of water. As such, they are stable elements (meaning they can not be metabolized by the food by the body) and bioaccumulative (passed up the food chain to humans) Heavy metals have no function in the body and can be highly toxic.

Heavy metals in textile wastewater represent a major environmental problem, and are a potential danger to human health. Heavy metals are often used as oxidizing agents, as metal complex dyes, dye stripping agents, fastness improvers, and finishers. Thus, they act as hazardous sources throughout entire textile processing.

These metals tend to mount up in the human part like liver, kidney, heart, bones and brain when they are absorbed in to our body from the textile and apparels. The effect on our health can be terrific when the accumulation of heavy metals reaches high level. (Kesavan & Parameswari, 2005).

The researcher in the present investigations tried to analyze heavy metal concentrations in ground water samples of selected villages around Bandi river of Pali due to heavy discharge of effluents of textile processing unit.

Table-12 indicates list of ground water samples collected from eight selected villages adjoining the Bandi river by different sources like open well, hand pump and river.

Table 12: List of groundwater sample sites for heavy metal analysis

G/W Samples	Site	Source
S_1	Jawadia	Open well
S_2	Kerala	Hand pump
S_3	Gadwada	River
S_4	Sukarlai	Open well
S_5	Dholaria	Hand pump
S_6	Nehda	River
S_7	Nehda Dam	Dam
S_8	Phankaria	Open well

Table 13: Heavy metal concentration in ground water samples of selected villages

S. No.	Heavy metal	Effluent standard	Ground water samples							
			S1	S2	S3	S4	S5	S6	S7	S8
1	Lead (Pb)	0.2 mg/l	0.27	ND	0.32	0.26	0.17	0.38	0.32	0.21
2	Copper (Cu)	2.0 mg/l	3.52	3.21	2.52	3.50	ND	3.99	4.21	2.12
3	Arsenic (As)	0.25 mg/l	0.32	0.26	0.25	0.33	0.21	0.37	0.43	0.27
4	Chromium (Cr) Hexavalent	0.25 mg/l	.57	ND	1.21	0.25	ND	1.71	1.88	ND
5	Zinc (Zn)	5.0 mg/l	2.1	2.23	3.22	3.72	ND	3.48	4.52	ND
6	Nickel(Ni)	1.0 mg/l	3.81	2.27	5.33	0.87	1.25	7.33	6.82	0.62
7	Cadmium (Cd)	0.03 mg/l	ND	ND	0.06	ND	ND	0.06	0.09	ND
8	Iron (Fe)	0.3 mg/l	0.35	0.25	0.22	0.32	0.25	0.52	0.57	0.22

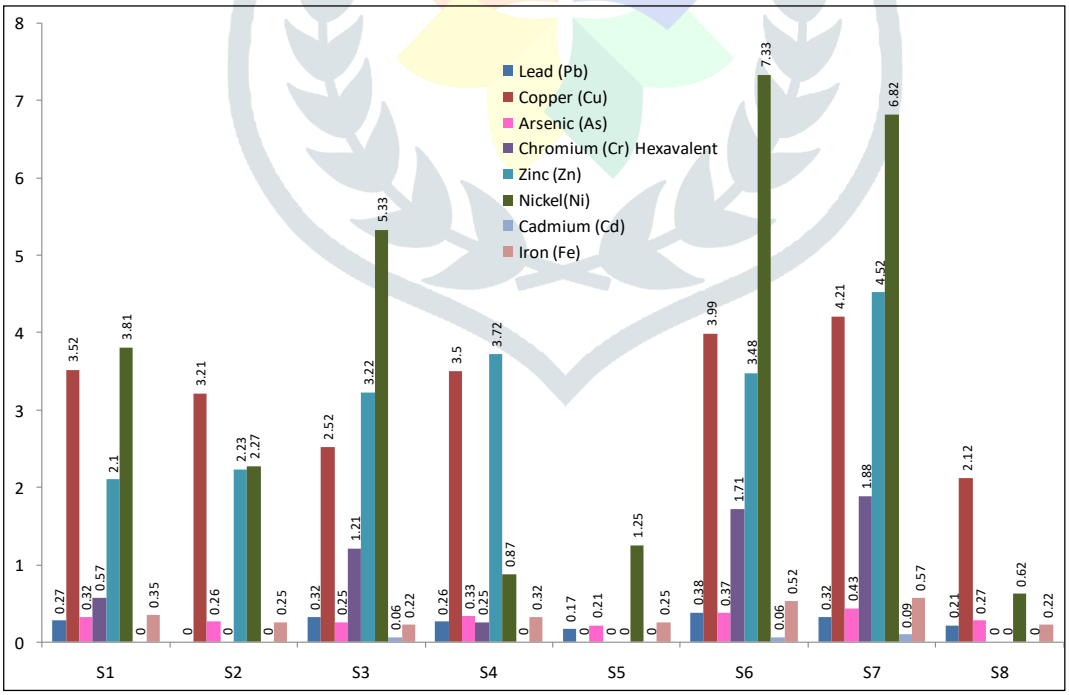


Fig.9: Heavy metal concentration in ground water samples of selected villages

Further, table-13 and fig.9 portrays the heavy metal concentrations in ground water samples of selected villages .Among heavy metal lead, copper, arsenic, chromium, zinc, nickel cadmium and iron were analyzed in the laboratory and compared with effluent standard.

The lead (Pb) concentration in the study area found to vary from 0.17 mg/l to 0.38 mg/l. It indicate that majority of the selected villages had violating effluent discharge standards. Maximum level of lead was found in river sample of Nehda village. Lead was not detected in the ground water samples of S2 and S5 as the water samples were taken from hand pumps.

Table clearly indicates that all the selected samples of groundwater had higher level of copper (Cu). Ground water samples S6 and S7 had near about two times higher level from effluent discharge standards. This may be due to the stagnation of effluents in water at Nehda Dam. The Nehda Dam was constructed with the object of meeting the water needs of nearby area for drinking and irrigation purpose but it has been found totally unfit for the purpose.

It was observed that Arsenic (As) concentration in the study area was found to vary within 0.21mg/l to 0.43 mg/l. Almost all the water sample except S5 village was violating the effluent discharge standard. At S7, it was about two times higher than standard value.

The standard value of chromium (Cr) is set up 0.25 mg/l according to pollution control Board. In the study area, the concentration of Chromium varied between 1.21 mg/l to 1.88 mg/l. The highest concentration of 1.88 mg/l was recorded in the sampling site of 'Nehda Dam'.

Similarly the zinc (Zn) concentration was found to be varied between 2.1 mg/l to 4.52 mg/l against the standard value of 5.0 mg/l. All the water samples were falling within the standard limit.

Further the data in table shows that concentration of Nickel in all the water samples exceeded the permissible limit. The standard value is not more than 1.0 mg/l. At Nehda village it was found seven times higher, followed by Nehda dam. Majority of the water samples collected recorded Cadmium concentration within the standards except samples S3 and S7, in which the values were found two and three times higher than standard value. The effluent standard of Iron is not more than 0.3 mg/l according to pollution control Board. In the study area, the concentration varied between 0.22 mg/l to 0.57 mg/l. Maximum concentration of cadmium was found in ground water sample S7.

Findings from the study showed that the hand pump water source was found less contaminated. Open well which were situated near to Bandi river possessed high level of heavy metal concentrations. Ground water sample of river which is flowing near to villages were exceeding the effluent discharge standards due to the reasons that textile effluent were directly discharged in the river. This shows that CETPs alone are incapable of treating and removing heavy metals, which are toxic in nature. The maximum level of heavy metal concentration was found at 'Nehda dam'. This dam was built for storing monsoon run-off to enhance irrigation of that area. Today, the dam has run as the death –knell for agriculture, villagers in and around Nehda due to the accumulation of textile effluents at the dam. There is need to properly monitor that no effluents get accumulated at the Nehda dam and the waste water stored at the dam site today, must be immediately flushed out to avoid further complicating the situations at this site.

The heavy metals particularly, lead (Pb), chromium(Cr), cadmium (Cd) and copper (Cu) are widely used for the production of colour pigments of textile dyes. Such heavy metals can exist in naturally in the structures of textile or they can penetrate into fiber of textile during production, dyeing process or through

protective agents used during storage. These heavy metals which have transferred to the environment are highly toxic and can bioaccumulate in the human body, aquatic life, and natural water-bodies and also possibly trapped in soil. (Mathur et al. 2005).

It was concluded that the heavy metals pollutants such as Cadmium, Arsenic, Chromium, Lead, Copper and Nickel were present in higher concentrations than the permissible standard value (WHO, 2003 BIS, 1999). When these heavy metals and their compounds are discharged to the water, soil, they cause pollution. They contaminate the rivers and streams and kill aquatic life. They pollute drinking water and enter in our foods, the consumption of which can cause adverse health effects in long run.

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