Int. J. Chem. Sci.: 14(4), 2016, 1929-1938
ISSN 0972-768X
www.sadgurupublications.com

ANALYSIS OF DYEING AND PRINTING WASTE WATER OF BALOTARA TEXTILE INDUSTRIES

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ABSTRACT

The textile effluents containing dye, printing and processing waste water of Balotra region were collected to study the concentration levels of different salts and metal ions in the effluents. Water samples were collected from ten different locations of Balotra region and various parameters were analysed viz pH, EC, TDS, COD, The concentration of Na^+, Ca^{2+}, Mg^{2+}, Cl^-, NO_3^-, F^- and the heavy metals (Cu, Fe, Cr, Ni, Zn, Pb Cd), which reveals that effluent discharge from the dyeing and printing textiles has great impact on the quality of water. The results show extreme variation from the standard WHO specifications. The samples were found to contain pH and electrical conductivity in the range 7.1 to 8.7 and EC from 2000 to 9000 µmhos/cm, respectively. The concentrations of biological oxygen demand (BOD) and chemical oxygen demand (COD) were found unexpectedly very high. A higher concentration of heavy metals was also detected. The concentration of nitrates and fluorides were very high from the limit set by WHO.

Key words: BOD, COD, Physico-chemical parameters, TDS, Textile industry.

Fig. 1: Map of Balotra (Courtesy: Google Maps)

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INTRODUCTION

Balotra town is situated about 100 km to the west of Jodhpur. The town is famous for its dyeing and printing process industries.[1] The effluent from these industries, which consists mainly dyes like Methylene Blue, Malachite Green, Rhodamine Band and various salts, is flushed into the nallah and Luni river.[2] Dyeing industries are located around Luni river and other water sources and are discharging foul smelling, coloured, liquid effluent in the river. A large amount of which is absorbed by the soil, causing water pollution. The farmers use the polluted water to irrigate their fields. The vegetables and crops so produced are consumed by the human beings resulting into a number of health hazards. The highly alkaline and saline water is also causing damage to ground water. For dyeing cloth, large amount of water is required by the industries, which is supplied by digging wells in the agriculture field.[3] High rate of water withdrawal has further deteriorated the quality of water. Textile industrial sector is one of the most important and largest sectors of Rajasthan with regard to production and labour force employment. Balotra city has got largest number of textile units in the state (more then 5000), which are engaged in cotton and synthetic dyeing and printing. These dyeing and printing units discharge about 100 million litres of effluent per day into the Luni river. The toxic components of the effluents find their way into the wells due to the underground water recharging. Textile process involves variety of chemicals depending upon the nature of raw materials and products. Environmental problems by these industries are mainly caused by the discharge of effluent.[4] The effluent thus produced causes substantial pollution in term of increase in COD, BOD, TDS, chlorides, sulphates and heavy metals like zinc, lead, copper, iron etc. Textile effluents, when discharged in nearby river, serves as major recharge source of fresh water for wells in monsoon causes severe contamination of ground and underground water. The indiscriminate use of excessive organic dyes has increased the toxic metal contents to undesirable level in effluents.[5] Main pollution in textile dyeing and printing waste water comes from dyeing, printing, and finishing processes. These processes require the inputs of a wide range of chemicals and dyestuffs, usually comprised of organic compounds of complex structure. Major pollutants in textile wastewater are suspended solids, detergents, dyes, acids, alkalis, colour, heavy metals and other soluble substances. Because all of them are not contained in final products, as such becomes waste and causes disposal problems. Environmental problem occurs due to current practice of discharging untreated effluents into the stream. Strong colour of effluents is one of the greatest environmental problems. The presence of even small amount of dye in water (1-2 mg/L) is highly visible and esthetical undesirable.[6] Most of the chemicals present in the effluents are non-biodegradable into toxic end products, so their concentration must be reduced to acceptable level before discharging into environment. In mid-February 2012, the high court issued an order stopping all units from dumping water into the river due to a pollution problem. About 700-800 unit were affected and closed down in Balotra and 34000-

45000 persons lost their jobs. Several voices were raised but it was only for a short period of time. A study has proved that in Balotara the water has so much fluoride that children are now being born with twisted bones. Still thousands of factories are running and are throwing untreated water to the drain and Luni river and playing with the health of human beings and other vegetation.

Fig. 2: Effluent water outside industrial area near Luni river

Study area

Balotra is located at 25°50′N 72°14′E/25.83°N72.23°E. It has an average elevation of 106 metres (347 feet) in Barmer district of Rajasthan state in India. It is about 100 km from Jodhpur. For 60 years, Balotra has been known as a leading centre in India for processing and trading of various types of fabrics. More than 5000 textiles units are located here. The town is famous for hand block printing and textile industry. In particular, Balotra is famous for its dyeing and printing of cotton and polyester fabrics.[7] There are many unregistered factories running, which are throwing industrial effuluent water into the drains and to Luni river making things worse. About half a million families in Balotra are affected due to contamination from effluents. The contaminated water has destroyed various crops like jowar, wheat, millet, vegetables, and fodder, which were grown earlier in this area.

Objective of the study

The objective of the present study is to analyse the physico-chemical parameters of the textile effluent and metal toxicants present in it. This will help in assessing the effects of effluents and waste water on human beings.[8] For this purpose, the quality of effluent water and underground water is monitored at various locations.

Fig. 3: Coloured effluent in Luni river, Balotara

EXPERIMENTAL

Materials and methods

Collection of samples

Effluent samples were collected from ten main industrial drainage sites, which were key locations of industrial effluent discharge. The water sample were collected in plastic bottles of two litre capacity. Before collecting water samples, these bottles were thoroughly washed with 10% HCl and rinsed with distilled water. The water samples were analysed using standard methods of chemical analysis of water and waste water.[9] The trace element such as Fe, Cu, Zn, Cd, Pb and Cr were determined by using atomic absorption spectrophotometer The water samples were filtered through 0.45 µm membrane filter and acidified with concentrated HNO_3 (AR grade) and the results were compared with WHO standard values (2003).

Table 1: BIS-standard parameters

Parameters	Permissible limit	Excessive limit
pH	6.5	8.5
Nitrate	45	100
Sulphate	200	400
TDS	500	2000
Chloride	250	1000
TA	200	600
TH	300	600
Fluoride	0.9	1.5

Table 2: Parameters and methods employed in the physic-chemical examination of water samples

S. No.	Parameters of water analysis	Method employed
1	pH	Potentiometric
2	Tempeature (^oC)	Thermometric
3	Conductivity (μS/cm)	Potentiometric
4	Turbidity (NTU	Nephelometric
5	Total dissolved solids	Gravimetric
6	Total alkalinity (as $CaCO_3$)	Titrimetric
7	Total hardness (as $CaCO_3$)	Titrimetric
8	Calcium hardness (as $CaCO_3$)	Titrimetric
9	Magnesium hardness (as $CaCO_3$)	Titrimetric
10	Chloride (as Cl^-)	Titrimetric
11	Nitrate (as NO_3^-)	Spectrophotometric
12	Sulphate (as SO_4^{2-})	Spectrophotometric
13	Fluoride (as F^-)	Ion selective electrodes
14	Sodium (as Na^+)	Flame photometric
15	Potassium (as K^+)	Flame photometric
16	COD	Titrimetric
17	BOD	Titrimetric, spectrophotometric

RESULTS AND DISCUSSION

Physicochemical analysis of surface water samples

pH: Observations presented in Table 4 clearly reveals that 10 effuluent water samples have pH between 6.9 to 8.6, which are slightly towards alkaline nature.

TDS and Electric conductivity: As far as the total dissolved solids (TDS) and electric conductivity (EC) values in surface water samples are concerned, all the ten samples showed their TDS (467-18040 ppm) and EC (2000-9000 μmhos/cm) value were higher than the standard limit. This indicates that all the samples were highly saline.

COD: Analysis of chemical oxygen demand (COD) in all the ten samples showed

COD in the range of 150-1289 ppm. The results of COD analysis showed that these are higher than the permissible limit of effluent standards.

Chloride: On analyzing chloride content in all the ten surface water samples, it was observed that none of the sample had the chloride content within the limit of the Indian standards.

Table 3: Permissible limits for effluent water to be sent to CETP

S. No.	Parameter	Concentration (mg/L)
1	pH	5.5-9
2	Temperature	45
3	Chromium	2.0
4	Lead	0.01
5	Cadmium	1.0
6	Arsenic	.2
7	Zinc	15
8	Mercury	.01
9	Nickel	3.0
10	Copper	3.0
11	Iron	1
12	Fluoride	15

Heavy metal analysis of surface water samples

All the ten effluent water samples were also evaluated for heavy metals (Zn, Ni, Cd, Fe, Cu, Pb and Cr) using Atomic absorption spectrophotometer (AAS). However, results show that heavy metals (Zn, Ni, Cd, Fe, Cu, Pb and Cr) were detected in all the samples.[10] Lead was detected only in four samples. The discharge of acids and alkaline materials from the textile, coal-fuelled and chemical industries disrupts the pH buffer system of the natural water, reducing its potential to kill harmful micro-organisms.

Balotara in Rajasthan has got largest number of textile dyeing and printing industries. More than 5000 units are mostly engaged in cotton and synthetic textile printing and dyeing. These industries liberate a variety of chemicals, dye, acids and alkali besides other toxic compounds like heavy metals. These units discharge their untreated effluent directly into river Luni. Further, increasing trend of requirement and productivity of dyes and dye intermediates is associated with generation of waste containing toxic and hazardous substances, which are not acceptable to the recipient environment, if released uncontrolled.[11] The compound of Cu, Pb, Cd, Fe, Cr and Zn are used in dyes, pigments printing inks, their salts such as potassium dichromate, copper sulfate, ferric chloride, lead chromate, chromium chloride etc. are used as mordants in textile dyeing and printing industry.[12] As it is clear from Table 1 that iron, lead, zinc, copper, nickel and chromium are present in alarming concentrations, while concentration of lead and chromium in industrial effluents exceed limit set by WHO for discharge of industrial surface water of 0.1 mg/L.[13]

Table 4: Physico-chemical analysis of industrial effluents

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Colour	Reddish	Brownish	Blue	Green	Orange	Orange	Brown	Black	Dirty brown	Blue-green
EC	8000	6500	2000	7000	9000	6500	2700	5900	6000	2000
COD	980	800	300	680	790	789	1289	760	455	150
Na^+	1100	1600	1179	2000	2700	1290	1000	1200	1900	450
pH	7.8	7.9	5.7	6.8	6.4	8.7	6.2	6.8	7.5	6.3
TDS	3200	1600	467	1600	1180	5180	18040	4210	1700	3200
Alkalinity	600	300	20	400	530	490	630	555	275	485
TH	1000	296	240	900	350	695	280	370	890	440
CaH	1200	400	16	800	120	500	300	290	560	290
Cl^-	600	570	190	1000	190	200	300	540	539	670
Cd	6.98	3.45	4.85	10.58	12.51	26.24	26.29	26.18	13.32	10.50
Cr	1.5	2.2	1.2	4.87	3.4	3.6	2.08	6.6	3.10	3.24
Ni	0.02	0.07	0.03	0.20	1.70	1.36	3.41	2.50	0.09	1.30
Fe	0.32	0.31	0.35	0.34	0.40	0.43	0.49	0.64	0.55	0.39
Cu	0.12	0.19	ND	ND	ND	ND	0.007	0.011	ND	0.05
Pb	0.04	0.13	0.08	0.14	0.09	0.07	0.01	0.12	0.08	0.11
Zn	0.04	0.05	0.03	0.05	0.05	0.04	0.041	0.05	0.038	0.05

The high levels of cadmium (3.45-26.24 mg/L), lead (0.12 mg/L) and chromium (1.2-6.7 mg/L), nickal (1,3-3.41 mg/L) and iron (0.33-0.55 mg/L) is a matter of environmental degradation as plants and animals are directly exposed to wastewater. The presence of toxic concentration of lead, chromium, cadmium and iron in effluent water illustrate the impact of trace metals by dyeing and printing industries functioning in Balotara.[14,15]

Iron: The higher concentration of iron leads to astringent taste, discoloration, turbidity, deposits and growth of iron bacteria in pipes. The BIS has prescribed maximum limit of iron in the industrial effluents that can be discharged into stream i.e. 3.0 mg/L.[16] The maximum permissible iron content in domestic water is up to 1.0 mg/L. the iron contamination is low and it varies with flow in river. Its content varies from 0.33 to 0.55 mg/L with an average of 0.025 mg/L.

Cadmium: The maximum permissible limit of cadmium in the effluent water supply is 1.0 mg/L. Consumption of cadmium salts causes cramps, nausea, vomiting and diarrhea. Cadmium tends to concentrate in lever, kidney, pancreas and thyroid of human being. The chemical data show that the effluent water samples generally contains its concentration ranging between 3.45 to 26.24 ppm, which is very high than normal limit.[17,18]

Lead: The maximum permissible limit of concentration of lead is 0.1 mg/L beyond, which water becomes toxic and can be injurious to health and even lethal, if taken for short or prolonged period. The BIS has prescribed maximum limit of lead in the industrial effluents for discharging into stream water as 0.1 mg/L. The concentration of lead in effluent water is a matter of concern.[19] The chemical analysis data show that nearly four samples contained lead more than the maximum permissible limit.

Chromium: The maximum permissible limit of chromium in effluent water is 2.0 mg/L. Above this limit, it may be carcinogenic. The BIS has prescribed maximum limit of chromium in the industrial effluent as 0.1 mg/L for discharging into stream.[20] All the effluent water samples contained 1.2 to 6.6 mg/L chromium, which is much more than the permissible limit.

Zinc: Water samples at all sampling stations were found to contain zinc in permissible limit. Zinc contents varied from 0.04 to 0.07 mg/L with an average of 0.04 mg/L.

CONCLUSION

The presence of high toxic concentration of lead, chromium, cadmium, nickle and iron in the industrial effluent of various factories indicates the fact that some of the dyeing and printing industries are not treating effluent water before throwing them in drain and then to Luni river. The river has been polluted due to higher concentration of trace metals significantly. Lead, chromium, cadmium, copper, iron, and zinc contents (Table 3) have been found to be far above the prescribed limit of 0.1, 3.0, 13.0, 1.0 and 15.0 mg/L in all effluent sample except at one or two sites. Heavy metals, if present beyond permissible limits in water are toxic to human beings, aquatic flora and fauna. In the present study, Pb, Ni, Cu, Fe and Cr are exceeding their permissible limits. It is quite evident that these heavy metals may enter the food chain, and through bioaccumulation can easily reach humans through plants and can cause various deadly diseases. Lead poisoning can leads to asthma, neurobehavioral disorders and can even lead to cancer. Chromium is also very toxic. Through inhalation and dermal route, it causes lung cancer, nasal irritation, nasal ulcer and hypersensitivity reactions like contact dermatitis and asthma. Workers working in these dyeing industries are mostly affected. Regular monitoring of the water quality is thus required to assess the heavy metal contents in the effluent water before throwing them to the nallah and drain so that remedial measures can be adopted to save the ground water from heavy metal pollution.

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Revised : 06.09.2016 *Accepted : 09.09.2016*