Available online at http://www.journalijdr.com

IJDR

ISSN: 2230-9926

International Journal of Development Research
Vol. 07, Issue, 07, pp.14199-14203, July, 2017

ORIGINAL RESEARCH ARTICLE

Open Access

IMPACT OF DYEING INDUSTRIAL EFFLUENTS ON THE GROUNDWATER QUALITY IN KARUR TOWN INDIA

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ARTICLE INFO

Article History:

Received 05th April, 2017
Received in revised form
27th May, 2017
Accepted 26th June, 2017
Published online 31st July, 2017

Keywords:

Amaravathy,
Physicochemical,
Industrial Effluent,
Treatment.

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ABSTRACT

The present study is about the presence of dye industries and how their effluents affect the ground water quality in Karur town, located in Tamil Nadu, India. The study also includes physical well water collection and analysis of the town was carried out during 2013 to 2015 to evaluate the physicochemical characteristics of water. Water sampling was collected for six seasons and this reveals that three year average of ground water samples collected from 35 wells distributed on both sides of the river Amaravathi justifies the results. The water analysis implied for 17 drinking water quality parameters indicates, interesting results, which need further interpretation based on the industrial locations and the people surrounding. The current practice of water usage, effluent treatment and discharge and sludge storage and disposal is not sustainable and would cause irreparable damage to the ecosystem while threatening the livelihoods of the farmers in the surroundings of the textile units.

Citation: Shanmugapriya, J., Dr. Senthil, J., Dr. Anand, P.H. and Dr.Indhira, K. 2017. “Impact of dyeing industrial effluents on the groundwater quality in karur town India”, *International Journal of Development Research*, 7, (07), 14199-14203.

INTRODUCTION

This paper attempts to focus on the drinking water quality of Karur town. Karur is an industrial town located on the banks of the river Amaravathi. It is located at 10.95^{o}N, 78.08^{o}E and 396 km from Chennai on southwest direction. Amaravathi river is a tributary to the river Kavery. It is confluences with river Kavery at about 12 km downstream of Karur. During the last four decades, the town emerged as a major textile centre with its 1000 odd power loom and handloom dye units producing bedspreads, towels and furnishing. There are about 1000 units along a 17 km stretch on the banks of river Amaravathi, which undertake bleaching, dyeing, weaving, tailoring, knitting, knotting, packing, transporting and trading.

There are 487 textile processing units in function and release about 14,610 kilo litres per day of treated effluent into the river, Amaravathy. The drinking water quality in the Karur town is contaminated due to continuous discharge of effluents. The present study evaluates the groundwater quality in and around the Karur town of Tamil Nadu with reference to drinking purposes. The textile industry is one of the most important and rapidly developing industrial sectors in India. It has a high importance in terms of its environmental impact, since it consumes considerably high amounts of processed water and produces highly polluted discharge water in large amounts. Dyeing and printing industrial wastes disposed both in liquid and solid forms in land and water bodies percolate into the groundwater and get transported in the direction of groundwater flow.

MATERIALS AND METHODS

Water sampling was carried out from 2013 to 2015 for two seasons every year. The sampling site in the present paper is dyeing industrial locations near to Amaravathy River in Karur town. Samples were collected from the 35 different sites of the selected area in a wide mouth plastic bottle. The site of sample collection was identified at point where the effluent is discharged from the industry. The colour of the effluent and smell was observed at the time of collection of the sample in spotlessly clean bottles. The waste water discharged from the textile industries is characterized by a variety of chemicals generated from dyeing and washing processes. It also constitutes suspended solids, organic and inorganic matters, acid and alkalis. Textile wastewater contains substantial pollution loads in terms of BOD, COD, and TDS. The environmental concern of discharged textile wastewater is mainly its high chemical oxygen demand (COD) as well as high strength of colour content. The analyses were carried out as per the standard methods.

DISCUSSION

The river Amaravathi dissects Karur town into major divisions, wherein 70 per cent of the chemical dye industries are located on the southern side and the rest are located on the northern side of the town. Dye is being used to apply chemical colors to fabrics, which are predominant ancillary household industry in Karur, which also supplies to the major industries located in Tiruppur and Coimbatore districts. Historically speaking, there were no treatment methods adopted to treat the chemicals from outlet waters, by the operators for the past four decades from 1970. The units other than household, has now set up industries with treatment plants are operations to let out the chemical water unharmed. At present there are five CEPTs' are operational three on the southern side and two on the northern side of the river. Setting up of CEPTSs' and the treatment plants in small industries might have reduced the chemical ground water pollution in the town, but the deposits of untreated chemicals that are settled in the ground water tables nearly three to four decades have still impact. This reveals that three year average of ground water samples collected from 35 wells distributed on both sides of the river Amaravathi justifies the results. The water analysis implied for 17 drinking water quality parameters indicates, interesting results, which need further interpretation based on the industrial locations and the people surrounding.

The pH level shows abnormal limits of 9.2, which has higher saline values and the rest of the wells in this town are well within the normal limits as prescribed by the Indian Standard Industries [ISI] and the World Health Organisation [WHO]. In terms of Total Dissolved Solids (TDS), the Environmental Protection Agency (EPA) advises against consuming water containing more than 500mg/liter, otherwise known as 500 parts per million (ppm) of TDS, although many health specialists believe that ideal drinking water should be under 50 ppm or lower. Among the drinking water samples in the town 18 samples have exceeded the limit as per the norms of the ISI and WHO. Abnormal limits of TDS of three year average indicate in the well locations of Thirumanilaiyur [6288], Andankoil East [5300], Karuppalayam [9570], Pasupathipalayam [6130], Melapalayam [6280], Senapadil [5430], Innamkarur [5460] and Vengampalayam [6570]. An elevated total dissolved solids (TDS) concentration is not a health hazard. The TDS concentration is a secondary drinking water standard and, therefore, is regulated because it is more of an aesthetic rather than a health hazard. Total hardness is a measurement of the mineral content in a water sample that is irreversible by boiling. Therefore, total hardness can be equivalent to the total calcium and magnesium hardness. Total hardness is determined by the multivalent cations' concentrations present in water. Hard water is not seriously harmful to human health. However, water with a high level of hardness could cause serious problems in industrial settings wherein water hardness is typically monitored to prevent costly failures in components like cooling towers, boilers and other equipment that contains or processes water. Total hardness in the dye industrial based town of Karur indicates that almost all the wells except 8 wells are in the abnormal limits of ISI and WHO standards.

Calcium concentration in water is clinically relevant for patients with osteoporosis for reasons besides that of adequate calcium intake. The bioavailability of bisphosphonates, one of the first-line therapies for osteoporosis, is hampered by concomitant ingestion of calcium. Bisphosphonates are bone antiresorptive agents used in the treatment and prevention of osteoporosis, hypocalcemia caused by malignancy, Paget's disease, and other bone resorptive conditions. Although their exact mechanism of action is not clear, bisphosphonates inhibit osteoclastic bone resorption at the mineral surface and enhance osteoclast apoptosis (cell death) by inhibiting membrane synthesis. As a result, bisphosphonates arrest bone loss, leading to quantifiable increases in bone mass, and decrease the risk of low-energy fracture. In the town except nine wells, all the remaining wells indicate high to very high calcium concentration in the water that will harm the underlying population.

The human body contains about 25 g of magnesium, of which 60 per cents present in the bones and 40 per cent is present in muscles and other tissue. It is a dietary mineral for humans, one of the micro elements that are responsible for membrane function, nerve stimulant transmission, muscle contraction, protein construction and DNA replication. Magnesium is an ingredient of many enzymes. Magnesium and calcium often perform the same functions within the human body and are generally antagonistic. There are no known cases of magnesium poisoning. High doses of magnesium in medicine and food supplements may cause muscle slackening, nerve problems, depressions and personality changes. It is unusual to introduce legal limits for magnesium in drinking water, because there is no scientific evidence of magnesium toxicity. Samples collected from the 35 wells indicate that except three wells all the remaining are having above the permissible limits of magnesium. Although it is generally agreed that sodium is essential to human life, there is no agreement on the minimum daily requirement. However, it has been estimated that a total daily intake of 120–400 mg will meet the daily needs of growing infants and young children, and 500 mg those of adults. In general, sodium salts are not acutely toxic because of the efficiency with which mature kidneys excrete sodium. However, acute effects and death have been reported following accidental overdoses of sodium chloride. Acute effects may include nausea, vomiting, convulsions, muscular twitching and rigidity, and cerebral and pulmonary oedema. Excessive salt intake seriously aggravates chronic congestive heart failure, and ill effects due to high levels of sodium in drinking-water have been documented.

Table 1 Physico-Chemical characteristics of groundwater in the study area

Sl. No	SAMPLE WELLS	pH	EC	TDS	$CaCo_3$	Ca	Mg	Na	K	HCo_3
1	Chellandi Palayam	7.36	1297	846	284	78	18	12.78	1.2	240
2	Thirumanilayur	7.88	9598	6288	2458	628	274	18.93	2.7	691
3	Govindampalayam	8.28	1489	939	268	58	19	12.45	0.98	147
4	Andankovil West	8.08	1767	766	273	59	18	7.86	0.47	154
5	Chettipalayam	7.95	5492	3688	1268	288	178	9.42	1.15	128
6	Thoranakalpatty	7.48	3176	2049	894	237	77	13.08	0.46	365
7	Thanthonimalai	7.97	2877	1449	247	68	26	9.41	0.97	298
8	Andankovil East	8.1	8200	5300	2608	586	234	17.25	2.71	487
9	Karuppalayam	7.42	9400	9570	976	304	28	10.07	0.55	152
10	Pasupathypalayam	9.2	7360	6130	1987	498	308	24.09	0.2	265
11	Balambalpuram	7.2	1240	860	1948	79	196	29.81	2.1	547
12	Arasu Colony	7.6	2060	1370	1217	134	42	13.32	1.3	560
13	Melapalayam	8.1	9325	6280	1987	436	210	7.41	0.43	380
14	Sukkaliyur	7.8	6430	4290	3120	34	86	17.08	0.94	311
15	Natarajapuram	7.4	1867	760	976	42	121	5.11	0.89	274
16	Kodiyur	7.24	1809	930	874	234	138	2.07	0.58	215
17	Senapadil	7.8	7462	5430	2460	305	282	9.42	2.71	387
18	Puliyur	7.1	1540	880	946	146	34	13.82	0.89	364
19	Innamkarur	8.1	6130	5460	1781	64	243	5.02	0.36	518
20	Vengampalayam	7.8	9400	6570	976	192	28	5.21	0.61	497
21	Kuppuchipalayam	7.4	4640	2800	1462	242	169	5.61	3.45	469
22	Punjai Pugalur	7.3	1585	1109	242	81	51	16.42	1.28	375
23	Arugam Palayam	7.4	1409	760	210	58	20	7.41	0.52	480
24	Thotta Kuruchi	7.2	1330	931	242	67	35	3.75	0.58	156
25	Achi Mangalam	7.3	1168	930	874	231	64	5.07	3.08	122
26	Kadapparai	7.6	2180	1320	849	146	42	0.75	0.15	179
27	Venna Malai	7.7	1040	540	976	194	51	12.02	0.61	386
28	Jawahar Bazar	7.5	828	280	1265	286	176	1.02	0.15	333
29	Amaravathi	7.2	4300	2860	208	55	17	10.72	0.61	299
30	Lgb Nagar	7.4	1120	348	2608	586	234	3.78	0.49	451
31	Mada Vilagam	7.5	2340	846	238	58	32	3.75	0.94	371
32	Kamadenu Nagar	7.6	1060	194	321	62	24	9.28	0.49	431
33	Vadivel Nagar	8.43	3482	2800	197	59	98	5.42	1.82	458
34	Thiruvai	7.42	1480	915	62	18	40	5.62	0.52	392
35	Vanchi	7.89	5892	3600	71	79	12	1.02	0.15	512

Continued …,

Sl. No	SAMPLE WELLS	So_4	Cl	Po_4	No_3	NH_4	BOD	COD	DO
1	Chellandi Palayam	64	238	0.06	7	0.05	2.7	6	6.9
2	Thirumanilayur	347	3819	0.08	27	1.32	8.8	38	6.2
3	Govindampalayam	58	247	0.46	7	1.38	2.9	14	6.9
4	Andankovil West	68	138	0.3	8	1.21	1.8	40	6.8
5	Chettipalayam	165	1628	0.16	7	0.09	3.8	18	7.2
6	Thoranakalpatty	276	688	0.3	28	0.6	2.7	28	6.8
7	Thanthonimalai	98	438	0.58	28	0.6	2.7	14	6.8
8	Andankovil East	294	3408	0.06	18	0.4	8.3	42	6.6
9	Karuppalayam	46	297	0.14	22	0.04	2.7	7	7.4
10	Pasupathypalayam	189	2986	0.03	32	0.12	7.6	32	6.2
11	Balambalpuram	218	2486	0.3	14	1.12	3.4	28	6.2
12	Arasu Colony	143	792	0.4	5	0.06	1.6	8	7.8
13	Melapalayam	298	3140	0.07	34	0.04	8.1	36	6.4
14	Sukkaliyur	92	683	0.04	8	0.3	7.4	23	7.2
15	Natarajapuram	78	432	0.18	16	0.2	6.3	12	8.1
16	Kodiyur	46	1026	0.2	6	0.02	2.7	4	6.3
17	Senapadil	148	2492	0.06	29	0.4	8.4	42	6.9
18	Puliyur	86	584	0.46	277	0.3	1.5	7	6.3
19	Innamkarur	134	1462	0.17	2	0.04	8.1	23	7.4
20	Vengampalayam	87	534	0.42	18	1.32	4.2	18	6.2
21	Kuppuchipalayam	124	741	0.2	28	0.03	3.7	6	7.1
22	Punjai Pugalur	73	214	0.04	12	0.32	2.4	5	6.7
23	Arugam Palayam	52	238	0.43	2	1.32	2.7	4	6.6
24	Thotta Kuruchi	65	198	0.47	11	0.07	2.7	6	7.2
25	Achi Mangalam	312	683	0.4	48	0.06	3.8	7	7.4
26	Kadapparai	122	986	0.61	0.21	0.07	4.6	21	6.8
27	Venna Malai	146	1246	0.43	0.04	0.78	8.3	28	7.1
28	Jawahar Bazar	115	1626	0.14	1	0.08	3.3	8	7
29	Amaravathi	55	241	0.45	1	1.33	2.1	4	6.8
30	Lgb Nagar	294	3408	0.06	18	1.21	8.3	42	6.6
31	Mada Vilagam	108	441	0.54	28	0.45	2.3	5	6.7
32	Kamadenu Nagar	126	546	0.56	29	0.04	2.1	4	6.8
33	Vadivel Nagar	72	281	0.36	12	1.41	2.7	8	6.9
34	Thiruvai	64	328	0.07	8	1.42	3.8	12	6.4
35	Vanchi	161	687	0.4	42	1.04	1.5	4	7.4

Source: Results of Bio-geo-chemical analysis from the lab.

The effects on infants are different from those in adults because of the immaturity of infant kidneys. Infants with severe gastrointestinal infections can suffer from fluid loss, leading to dehydration and raised sodium levels in the plasma (hypernatraemia); permanent neurological damage is common under such conditions. Among the 35 water samples and computed for three year average implies that sodium values in all the samples are in abnormal state. There is a growing movement to use potassium in conjunction with sodium to treat and soften drinking water. This would cause the level of potassium in drinking water to rise. The World Health Organization (WHO) found that the level of potassium found in drinking water would present no health concerns for healthy adults; however, for certain populations with comprised renal functions, such as infants or individuals suffering from specific diseases, there is the possibility of adverse health effects. Potassium levels in all the 35 well samples are in the abnormal limits and it may affect specific target population those who are susceptible. Bicarbonate is one component of alkalinity and its concentration is in a balance with carbon dioxide between the pH range of 4.4 and 8.2 and in a balance with carbonate between the pH range of 8.2 and 9.6. Majority of the wells in the town have above the normal limits [50-300] of alkalinity. Sulfates are discharged into water from mines and smelters and from kraft pulp and paper mills, textile mills and tanneries. Sodium, potassium and magnesium sulfates are all highly soluble in water, whereas calcium and barium sulfates and many heavy metal sulfates are less soluble. Ingestion of 8 g of sodium sulfate and 7 g of magnesium sulfate caused catharsis in adult males.

Cathartic effects are commonly reported to be experienced by people consuming drinking-water containing sulfate in concentrations exceeding 600 mg/liter, although it is also reported that humans can adapt to higher concentrations with time. Dehydration has also been reported as a common side-effect following the ingestion of large amounts of magnesium or sodium sulfate. Children, transients and the elderly are such populations because of the potentially high risk of dehydration from diarrhoea that may be caused by high levels of sulfate in drinking-water. Erratic concentrations of sulphates are found in the sample wells of Karur town though they are within normal limits and hence there in no major health hazards are expected. Chloride in surface and groundwater from both natural and anthropogenic sources, such as run-off containing road de-icing salts, the use of inorganic fertilizers, landfill leachates, septic tank effluents, animal feeds, industrial effluents, irrigation drainage, and seawater intrusion in coastal areas. Chloride toxicity has not been observed in humans except in the special case of impaired sodium chloride metabolism, e.g. in congestive heart failure. Healthy individuals can tolerate the intake of large quantities of chloride provided that there is a concomitant intake of fresh water. Concentration of Chloride is in abnormal state due to various dye pollution in the town and in some of the sample wells namely, Thirumanilayur [3819], Chettypalayam [1628], Andankovil East [3408], Pasupathypalayam [2986], Balambalpuram [2486], Melapalayam [3140], Senapadil [2492], Innamkarur [1462], Vennamalai [3408] are in abnormal limits prescribed by WHO and ISI. Rest of the wells are within the normal limits. The Environmental Protection Agency (EPA) has set the Maximum Contaminant Level (MCL) of nitrate as nitrogen (NO3-N) at 10 mg/L (or 10 parts per million) for the safety of drinking water. Excess nitrate affects the infant's health and 'blue baby' is common disease if excess nitrate is consumed through ground water. In the study area excess nitrate concentration wells are found in 21 wells and the rest of them are within normal limits of the WHO standards. Natural levels in ground waters are usually below 0.2 mg of ammonia per litre. Higher natural contents (up to 3 mg/litre) are found in strata rich in humic substances or iron or in forests. Surface waters may contain up to 12 mg/litre. Ammonia may be present in drinking-water as a result of disinfection with chloramines. In almost all the sample wells are above the abnormal limits of 0.2 mg/l in Karur town.

Biochemical oxygen demand (BOD) is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions. Biochemical Oxygen Demand is an important water quality parameter because it provides an index to assess the effect discharged wastewater will have on the receiving environment. The higher of the BOD value, the greater amount of organic matter or "food" available for oxygen consuming bacteria. BOD is high in 6 well locations and the remaining wells are within the normal limits of World Health Organization. Biochemical oxygen demand is a measure of the quantity of oxygen used by microorganisms (e.g., aerobic bacteria) in the oxidation of organic matter. Natural sources of organic matter include plant decay and leaf fall. However, plant growth and decay may be unnaturally accelerated when nutrients and sunlight are overly abundant due to human influence. Urban runoff carries pet wastes from streets and sidewalks; nutrients from lawn fertilizers; leaves, grass clippings, and paper from residential areas, which increase oxygen demand. Oxygen consumed in the decomposition process robs other aquatic organisms of the oxygen they need to live. Organisms that are more tolerant of lower dissolved oxygen levels may replace a diversity of natural water systems contain bacteria, which need oxygen (aerobic) to survive. Among the sample wells in the study area 8 wells are above the normal value of 6 and the rest of the wells are well within the normal limits.

Chemical oxygen demand (COD) is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as ammonia and nitrite. COD measurements are commonly made on samples of waste-waters or of natural waters contaminated by domestic or industrial wastes. Chemical oxygen demand is measured as a standardized laboratory assay in which a closed water sample is incubated with a strong chemical oxidant under specific conditions of temperature and for a particular period of time. A commonly used oxidant in COD assays is potassium dichromate, which is used in combination with boiling sulfuric acid. Because this chemical oxidant is not specific to oxygen-consuming chemicals that are organic or inorganic, both of these sources of oxygen demand are measured in a COD assay. The normal value of COD is 4. In the Karur town, among the 35 well samples, except 5 wells remaining 30 wells are within the abnormal limits of COD. In some well samples that has exceeded the value of 30. Total dissolved gas concentrations in water should not exceed 110 percent. Concentrations above this level can be harmful to aquatic life. Fish in waters containing excessive dissolved gases may suffer from "gas bubble disease"; however, this is a very rare occurrence. The bubbles or emboli block the flow of blood through blood vessels causing death. External bubbles (emphysema) can also occur and be seen on fins, on skin and on other tissue.

Aquatic invertebrates are also affected by gas bubble disease but at levels higher than those lethal to fish. Adequate dissolved oxygen is necessary for good water quality. Oxygen is a necessary element to all forms of life. Natural stream purification processes require adequate oxygen levels in order to provide for aerobic life forms. As dissolved oxygen levels in water drop below 5.0 mg/l, aquatic life is put under stress. Lower the concentration, greater will be the stress and the normal value is denoted between 4-6 Mg/l. When compared to the observed sample values of the 35 well locations in Karur town shows that DO is marginally higher in almost all the wells.

Conclusion

From the above results and discussions, it is evident that quality of groundwater in the study area is not suitable for drinking purposes. It focused for appropriate treatment, disposal and management of pollutants. Effective collection, treatment and disposal of industry wastes can help to protect the environment and ensure sustainable development. It affected peoples' health, environmental condition, soil and water quality. Ground water when once get polluted, its purification is too difficult. The result indicating that the application of textile effluent/polluted water affects physico-chemical properties of soil. This study also reveals that effluent from river bed was highly polluted. There is urgent need to follow effluent treatment methods before their discharge to surface water for reducing their potential environmental hazards.

Acknowledgement

The authors would like to sincerely thank Post Graduate and Research Department of Geography, Government Arts College (Autonomous), for providing the facilities for the preparation of this paper.

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