Water quality assessment in a textile dyeing industrial area

KALEESWARI, S
(12PZO004)

Thesis submitted to
Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore – 641 043

In partial fulfilment of the requirements for the Degree of

MASTER OF SCIENCE IN ZOOLOGY

MARCH, 2014

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Signature of the
Head of the Department

Signature of
the Supervisor

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INTRODUCTION

1. INTRODUCTION

Population explosion, hap hazardous rapid urbanization, industrial and technological expansion, energy utilization and waste generation from domestic and industrial sources have rendered may water resources unwholesome and hazardous to man and other living resources. Water pollution is now a significant global problem (Anetor *et al*., 2003).

Industrialization is the index of modernization which leads to alteration in physical, chemical and biological properties of environment. The history of civilization reveals that water sources and civilization run parallel. The era of unlimited fresh water supply is coming to end due to pollution of water sources owing to the increasing discharge of large volume of wastewater and toxic nature of wastes (Mahapatra and Singh, 1998).

The degradation of the environment due to the discharge of polluting wastewater from industrial sources is a real problem in several countries. The situation is even worse in developing countries like India where little or no treatment is carried out before the discharge (Behera *et al*., 2002).

Tanneries and textile dyeing and finishing are the two sectors among the various growing industries that contribute more to environmental degradation, more specifically to water pollution. Water pollution occurs due to the letting of untreated industrial effluents into rivers and open spaces around industries. Leather industries, tanneries, paper mills, sugar mills, dyeing industries along with other industries release their effluents into the adjacent rivers or allow them to stagnate on land. These effluents seep through the soil and pollute the ground water.

One of the industries under the strong radar of the environmental agencies is the dyeing units and the dyestuff industries as a whole. Next to food, the second basic need of man "Cloth" is supplied by processing of natural and synthetic fibers in the industries called textiles.

The impact on the environment by textile industry has been recognized both in terms of discharge of pollutants and consumption of water and energy (Lacasse and Baumann, 2006). Environmental problems of the textile industry are mainly caused by discharges of wastewater. The textile sector also has a high water demand. Its biggest impact on the environment is related to primary water consumption (8-100m^3 / ton of finished textile) and wastewater discharge (115 – 175 kg of COD / ton of finished textile) (Rosi *et al.,* 2007). Main pollution in textile wastewater comes from dyeing and finishing processes. These processes require the input of wide range of chemicals and dyestuffs, which generally are organic compounds of complex structure. Because all of them are not contained in the final product they become the waste and cause disposal problems (World Bank, 2007).

Wastewater from textile industries creates a great pollution problem due to the dye content. The inefficiency in dyeing processes has resulted in 10-13 % of unused dyestuff entering the wastewater directly (Spadarry *et al*., 1994). Colour present in dye effluent gives a straight forward indication of water pollution. Azo dyes constitute the largest group of synthetic dyes with great deal of structural and colour variety. They are extensively used in textile, leather, food, cosmetics, pharmaceutical and paper industries and eventually more than $7X10^5$ tonnes of these dyes are produced annually world wide (Keck *et al*., 1997). Azo dyes are potential mutagens and carcinogens which necessitate proper degradation and proper disposal (Paran *et al*., 2008). Some of the azo dyes and their dissociated products are also strongly toxic and mutagenic to the living organisms (Pinheir *et al*., 2004).

Natural pigments used for colouring textiles have been replaced by "fast colours" which do not fade on exposure to light, heat and water. These features unfortunately go with the perils of harmful effluent quality. About 15% of the dyes used for textile dyeing are released into processing water (Mishra and Tripathy, 1993). Besides being unaesthetic, these effluents are mutagenic, carcinogenic and toxic (Chung *et al*., 1992). More than 10,000 dyes are used in the textile industry and 28,000 tonnes of textile dyes are discharged every year world wide (Hsueh *et al*., 2005).

One of the main sources with severe pollution problems world wide is the textile industries and its dye – containing waste water. 10 – 25% of textile dyes are lost during the dyeing process and 2 – 20% is discharged as aqueous effluent in different environmental components. Textile industries play a very important role in degrading the water quality by releasing their effluents in rivers, lakes and oceans (Zaharia *et al*., 2011).

Most of the Indian rivers and freshwater streams are seriously polluted by textile dyeing and printing industry effluent, which includes wastes like metals, detergents, acids, alkalis, sulphates, chlorides, nitrates, dissolved and suspended solids, organic and microbial impurities (Naik and Choukarath, 2002).

River systems are the primary means for disposal of waste, especially the effluents from industries that are near them (Sangodoyin, 1991). High levels of pollutants in river water systems causes an increases in BOD, COD, TDS, TSS, toxic metals such as Cd, Cr, Ni and Pb and fecal coliforms and hence make such water unsuitable for drinking ,irrigation and aquatic life (Otokunctor and Obenkwu, 2005).

Due to population and industrial growth, inland waters become often the recipient of organic matter in amounts exceeding their natural purification capacity, whereas in the past, natural purification and dilution were usually sufficient.

Discharge of pollutants to a water resource system from domestic sewers, storm water discharges, industrial wastes discharges, agricultural runoff and other sources, all of which may be untreated, can have both short term and long term significant effects on the quality of a river system (Singh, 2007).

Rivers are vital and vulnerable fresh water systems that are critical for the sustainability of all life. However, the declining quality of the waters in these systems threatens their sustainability. Rivers are water ways of strategic importance across the world, providing main water resources of domestic industrial and agricultural purposes (Jain, 2009).

Generally chemicals and heavy metals from industries are thrown into ponds, streams, drains and opera fields through which they reach the ground water. As a result of this, the ground water gets polluted (Shamim *et al*., 2004).

Textile dyeing and finishing processes produce large quantities of waste water that is highly coloured (Mass *et al*., 2005). Apart from the aesthetic problems created when coloured effluents reach the natural water currents, dyes, strongly absorb sunlight, thus impeding the photosynthetic activity of aquatic plants and seriously threatening the whole ecosystem (Slokar *et al*., 1998).

Ground water serves as a major source for drinking, irrigation and industry. Ground water is highly valued because of certain properties not possessed by surface water. Water gets polluted due to contamination by foreign matter such as microorganisms, chemicals, industrial or other wastes or sewage (Jammeel and Sirajudeen, 2006).

Water quality is a major problem in many countries of the world. Due to its replenishing nature and less susceptibility to pollution, ground water is more trusted than surface water. However, due to close relations between surface water and ground water chances of contamination are more. Once the ground water is contaminated, it quality cannot be restored by stopping the pollutants from the source (Ramakrishnanah *et al*., 2009). Water quality characteristics of aquatic environment arise from a multitude of physical, chemical and biological interaction. A regular monitoring of water bodies with required number of parameters in relation to water quality not only prevents the outbreak of diseases but also help to mitigate occurrence of hazards (Khalid *et al*., 2011).

Consumption of polluted water has a significant effect in human health, balance of aquatic ecosystems, socio-economic development and prosperity (Malavarovic, 2007).

Textile industry in India is one of the oldest and largest organized sectors. Textile processing industries now-a-days are widespread in developing countries. In Tamil Nadu, textile dyeing industries are located in the districts of Erode, Tiruppur, Karur, Salem and Coimbatore.

Hence, an attempt has been made to assess water quality in a textile dyeing industrial area in Tiruppur district, Tamil Nadu, which is the textile hub of India.

The study was undertaken with the following objectives,

1) To monitor water quality in an industrial area.
2) To assess the impact of textile dye waste water on surface and groundwater quality in a textile dyeing in such areas.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

For the present study on the Water quality assessment of textile dyeing in industrial area the relevant literature was reviewed as follows.

Characteristics of Textile dye effluent

Impact of dye industrial effluent on physicochemical characteristics of Kshipro river, Ujjain city, India was analysed by Ahmed *et al*. (2012). The waste water has greatest potential for polluting the receiving water. River Kshipro one of the sacred Indian rivers is being polluted by effluents discharged from Bhairavgarh dye industires. The most common textile processing unit consists of desizing, scouring, bleaching, mercerizing and dyeing process. The present study was an attempt for assessment of water quality being polluted by effluents. Selected parameters include pH, temperature, electrical conductivity, total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), chemcial oxygen demand (COD), total alkalinity, total hardness and chloride content. These were monitored in the untreated effluent and receiving watershed following standard protocol. High levels were observed in COD, pH, TS. TDS, DO, total hardness which exceeds the standard levels of BIS and world health organization. The study revealed that there was an adverse impact of physicochemical characteristics of river Kashipro as a result of direct discharge of untreated effluents from Bhairargorh dye industries. This poses a health risk to several rural communities which rely on the receiving water bodies primarily as their source of domestic water.

Industrial effluents are characterized by their abnormal turbidity, total suspended solid (TSS), biological oxygen demand (BOD) and total hardness. Industrial wastes containing high concentration of microbial nutrients would obviously promote an after growth of signigicantly high coliform types and other microbial forms (Kanv *et al*., 2011).

Vyas (2011) observed that the waste water from different dyeing units in Agra city contain most of the physicochemical parameters in the range higher than the MPL (Maximum Permissible Limit). The waste water samples also showed the presence of toxic heavy metals, Pb, Cr, Cd and Zn. Characterization of textile dyeing waste water was carried out by Sekar *et al.* (2009). The textile waste water was obtained from a textile industry at Tirupur. Samples taken were preserved in the refrigerator at 4°C in accordance with the standard methods for the examination of water and waste water. The characterization of the raw effluent was done by collecting raw effluent samples from equalization tank in the industry. The waste water samples were characterized in terms of their colour, absorbance in nm (0.433), COD (1706mg/l), pH (8.8), Chlorides (mg/l 396), BOD (420mg/l), Sulphates (450mg/l), total suspended solids (l 50mg/l) and total dissolved solids (mg/l 3660).

Ali *et al.* (2009) analyzed the physico chemical and bacteriological status of a local textile mill effluent and found considerably high values of temperature (40°C) pH (9.50), EC (3.57 µs/m), BOD (548 mg/l), COD (1632 mg/l), TSS (5496 mg/l), TDS (2512 mg/l) heavy metal iron (0.28 – 6.36 mg/l) and colour above the prescribed fresh water limits.

Mathur *et al.* (2004) carried out the mutagenicity assessment of effluents from textile dye industries of Sanganer town, Jaipur. Sanganer town has about 400 industries involved in textile printing processes. Effluents from these industries contain highly toxic dyes, bleaching agents, salts, acids and alkalis. Heavy metals like cadmium, copper, zinc, chromium and iron are also found in the dye effluents. Environmental genotoxicity of the effluent was carried out using the Ames Salmonella / microsome mutagenicity assay. The results clearly indicate that the effluents and the surface water of Amanishab drainage have high mutagenic activity.

GROUND WATER POLLUTION

Ground water quality of Sukkaliyur at Karur was studied by Hussain and Rajadurai (2013). Sukkaliyur is one of the village in Karur. Industries of diverse fields such as textiles, dyeing, dairy and small scale industries are located in and around Sukkaliyur. The samples were subjected to physico-chemical analysis. High concentration of electrical conductivity, alkalinity, total dissolved solids, sodium, nitrate, chloride and sulphate were observed in most of the ground water samples.

Ground water contamination as a result of dyeing industries effluents in Erode District, Tamil Nadu was evaluated by Purushothaman *et al*. (2013). Ten (10) sampling locations were selected in and around industries. The water samples were collected from the selected sampling points. The samples were analyzed for major chemical water quality parameters like pH, EC, Ca, Mg, Cl, SO_4, Na, CO_3 and HCO_3. The present investigation shows a constant variation in different parameters in different locations. So it is highly important to take periodical monitoring of the ground water quality in this region for future sustainability.

Peiyue Li *et al.* (2013) Assessed the groundwater pollution in an industrial park in northwest China, where domestic water requirements are solely met by groundwater. The main contaminant and their sources were analyzed. The study showed that groundwater has been contaminated by natural processes, industrial and agricultural activities. The results of water quality assessment suggest that half of the groundwater samples collected were of medium quality and require pretreatment before human consumption.

Groundwater quality of the Tiruppur district in Tamil Nadu was investigated to develop a Water Quality Index (WQI) model. Hydrochemical parameters showed tremendous variation in certain location over the seasons. Ionic chemistry of groundwater suggested that textile industries and rock-water interaction are major threats to the water quality. Analysis of Na and Ca concentration indicates that direct as well as the inverse cation exchange controls the natural cation chemistry. NO_3 concentration shows that the pre-monsoon samples were affected by the fertilizer usage in agricultural fields. Na-Cl type of the water was dominant throughout the study area except few locations. WQI showed that 55% of the pre-monsoon samples and the 47% of the post monsoon samples were classified as poor/very poor/unsuitable for drinking category. Leaching of the textile waste and their transport to the downstream was well observed during the post-monsoon season. The specific contribution of river Noyyal in the transport of the solutes to the discharge zones was proved by the hydrochemistry of the samples (Kumar and James, 2012).

Ground water contamination due to human activities is a real and growing threat in many places in Tamil Nadu. The physico chemical quality of ground water was analysed in the Palar riverbed near Vellore, Tamil Nadu .The effluents from leather and small scale dyeing industries flowing into river has altered the ground water quality of the river bed (Pranavam *et al*., 2011)

Chemical properties of groundwater sources situated near river Bandi in the downstream to Pali were studied to assess the environmental impact of the dyeing and printing industry. The impact of the waste water of the dyeing and printing units was clearly noticeable in the study area. The ground water became highly polluted and had TDS above 3,000 mg/L. No source in the study area was found to be suitable for irrigation as well as drinking (Husain and Hussain, 2012).

To study the impact of textile dye effluent on ground water quality, Rajamanikam and Nagan (2010) assessed the quality of well water from 13 open wells in the river basin around Karur. They observed that TDS, total alkalinity, total hardness, calcium, chlorides and sulphates exceeded the desirable limit thus creating a severe impact on the ground water quality mainly in the downstream. The best option to protect the ground water quality in the river basin is that the textile processing units should adopt zero liquid discharge (ZLD) system by completely recycling the treated effluent.

Ground water quality assessment nearer to the dye industry was done by Sonawanea and Shrivastava (2010). The water quality index (WQI) was calculated for the assessment. For the calculation of WQI physicochemical characteristics of groundwater nearby dyeing-printing, pulp-paper and tanning industrial areas were studied. Various physicochemical parameters such as pH, total dissolved solids, total hardness, total alkalinity, calcium, magnesium, chloride and dissolved oxygen etc have been calculated in all the samples. In some of the parameters the concentration observed were found to be above the permissible limits of World Health Organization (WHO), Bureau of Indian standard (BIS) and Indian Council of Medical Research (ICMR).

Shymala *et al.* (2008) analyzed the physico – chemical parameters of borewell water samples of Telungupalayam area in Coimbatore and concluded that the effluents from dyeing units play a vital role in toxicating the ground water quality.

A systematic study has been carried out by Geetha *et al.* (2008) to assess the effect of textile effluents on Noyyal river basin of Tirupur town. Twenty six sampling locations were selected at random and the ground water samples were collected mostly from tube wells at Noyyal river basin in and around Tirupur area. The samples were analysed for major physical and chemical water quality parameters like pH, alkalinity, EC, TDS, TH, Ca, mg, Na, K, Cl and SO_4. It was found that the underground water quality was contaminated at few sampling sites due to the industrial discharge of the effluents on to the river or land from the Tirupur town. The study also concludes that the underground water quality in this region shows a constant variation in different parameters in different seasons. So it is highly important to take periodical monitoring of the underground water quality in this region for future sustainability.

Kannan *et al.* (2005) have investigated the physico-chemical characteristics of ground water samples mixed with effluents discharged from the textile industries at Chellandipalayam (site – I), Sanapiratti (site – II) and pasupathipalayam (site – III and IV) in Karur district, TamilNadu, India. Results reveal very high levels of Ca, mg, Na, Cr, K, Ni, Cu, Zn, CO_3, SO_4, NO_3 and Cl. The concentrations of these ions exceed the limit prescribed by ISI. The increase in the concentrations of ions has been revealed by higher values of electrical conductivity. The textile industries get raw materials from dyeing industries.

Mutagenicity assessment of effluents from textile / dye industries of Sanganer town in Jaipur was reported by Mathur *et al.* (2004). A low level of mutagenicity in the underground water of sanganer, Jaipur again emphasizes the grave pollution problem existing in the area.

Piska and Reddy (2002) studied ground water pollution due to the industrial effluents in Kothur industrial area, Mahboobnagar, Andhra Pradesh. Many textile and ceramic industries are located in this area and are generating large amount of effluents. Eighteen samples are analysed for twelve physico-chemical parameters of ground water – pH, EC, total dissolved solids, total suspended solids, total alkalinity, total hardness, calcium, magnesium, chlorides, sulphates, nitrates and fluorides. All the parameters except nitrates and fluorides are in high concentrations, most of them above the permissible limits and are responsible for ground water and surface water pollution.

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Senthilnathan and Azeez(1999) assessed Influence of Dyeing and Bleaching Industries on Ground Water of Tirupur, Tamilnadu, India by About 765 dyeing and bleaching industries operate in Tirupur (11° 7' N and 77° 15'E), located on the banks of the river Noyyal, a tributary of the river Cauvery. These units, using about 150 chemicals, discharge more than 7500 M3 of effluent without treatment everyday into the river Noyyal and wetlands in the vicinity. As a result, the ground water quality of entire town has turned hazardous and unfit for use. The present study was attempted to generate baseline data on the extent of ground water pollution in Tirupur and help delineate the area of contamination in predicting the possible risk to the population using ground water for domestic purposes and irrigation.

Surface water pollution

Mohan and Vanalakshmi (2013) assessed the water quality in Noyyal river through water quality index Water samples were collected from the Noyyal river at a stretch of 3800 m. The sampling locations have been fixed at every 50 m. The parameters were estimated such as dissolved oxygen (DO), pH, Temperature, chemical oxygen demand (COD), total dissolved solids (TDS), sulphate, chloride, total hardness etc. This study had two phases. In the first phase, the estimation of water quality parameters was carried out and in the second phase water quality index have been determined based on the existing standards. The effects of municipal sewage on river water quality have also been investigated. The depletion of DO concentration due to the simultaneous effect of water pollution, thus leads to more uncertainty about the survival of DO dependent aquatic species. From the study, it revealed that TDS, sulphate, chloride, and hardness were estimated to be high concentration at sampling location 10 (S10). Among the sample locations, in most of the places, high concentration of TDS, Hardness, sulphate and chloride and low level of DO were observed. Our findings highlighted the deterioration of water quality in the river and are due to human activities. This analysis reveals that the surface water needs some degree of treatment before consumption.

Characterisation of textile waste water discharges in Nigeria and its pollution implications was studied by Uwidi and Ejeomo (2013), such as temperature, pH, suspended solids (SS), total solids

(TS), permanganate value (PV), biochemical oxygen demand (BOD) and chemical oxygen demand (COD). The study revealed that the textile waste water were untreated and contained high amount of pollutants. These pollutants are discharged daily into nearby receiving surface water. There is need to prioritize action to minimize rapid depletion of dissolved oxygen in the receiving water so as to prevent "oxygen say" in the water. There is also a need a protect the quality and portability of the receiving surface water so as to reduce its adverse health implications on consumers in the surrounding environment.

Industrial waste waters entering a water body represent a heavy source of environmental pollution in Nigerian rivers. It affects both the water quality as well as the microbial and aquatic flora (Kanu *et al*., 2012).

Rathore (2011) assessed the water quality of river bandi affected by textile dyeing and printing effluents, pali, Western Rajasthan, India . The river carries exclusively industrial effluents throughout the year except in monsoon period. The study revealed that the chemical parameters – COD(993 mg/L), suspended solids (800 mg/L),chloride (1702 mg/L), sulphate (943 mg/L), sodium (2163 mg/L) and Cr^{+6} (0.15 mg/L) have exceeded the maximum discharge limits laid down by Bureau of Indian Standards. A decrease in concentration of various pollutants downstream Pali during monsoon season was observed due to dilution of industrial waste waters by the flow of fresh water upstream of Pali city.

The study was carried out in order to assess the impact of the various pollutants of textile dyeing effluents on the surface water quality of the industrial area inside Dhaka – Narayanganj – Demra (DND), embankment, Narayanganj. Physico-chemical parameters such as TSS, TDS, DO, pH, EC, turbidity, BOD, COD, anionic parameters such as Fl, Cl, NO_2, NO_3, SO_4, PO_4 and heavy metals such as Pb, Zn, Cd, Cu, of the samples were investigated. The results showed that textile dyeing industries inside DND Embankment area discharged effluents composed of various physico-chemical and anionic pollutants at considerably higher level compared to pollution limit. Further the surface water of the DND channel, ponds and Lakes around the studied textile dyeing industries also contain various physico – chemical and anionic pollutants at intolerable limit. A significant correlation was also observed among some important water parameters of the effluents and surface water. The above findings point out that the surface water around the studied textile dyeing industries in highly polluted by the industrial activities of the DND embankment area and found not good for human consumption Mahfuza *et al.* (2009).

MICROBIOLOGICAL CONTAMINATION

Kolarević *et al.* (2012) investigated the level of sanitary pollution and organic contamination of the Velika Morava river, the largest river in Serbia. Samples of water for microbiological analysis were collected at 5 sites, monthly, from April 2010 to February 2011. Sanitary analysis, i.e. enumeration of total and fecal coliforms and intestinal enterococci, indicated moderate to critical fecal contamination, while organic load assessment (oligotroph to heterotroph ratio, index of phosphatase activity) revealed the category of moderately polluted water. We also investigated seasonal variations of these groups of bacteria and the factors that could contribute to these differences. Our results showed that the microbiological quality of the water in the Velika Morava river during different seasons is affected by numerous factors such as unequal loading of wastewaters, solar irradiation, and relations of flow/dilution and rainfall/runoff.

Bacterial profiles of water samples from different sites of the New Calabar river, Niger was evaluated by Efiuvwev (2012). Water samples were collected from three sites (Ogbakiri, Choba and Iwofe). Bacterial isolates consisting mainly of gram-negative bacteria were (*Escherichia coli, Proteus vulgaris, Acinetobacter* spp, *Pseudomonas aeruginosa*, *Enterobacter aerogenes, Klebsiella* spp., *Vibrio* sp. and *Nocardia asteroides*) were isolated from the samples. The highest total coliform counts $\log_{10}$ 2.9 were encountered in water samples from Iwofe but the lowest counts $\log_{10}1.9$ occurred in the water samples from Ogbakiri.

Fatombi *et al*. (2012) analysed physical, chemical and microbiological parameters of river water and groundwater from Lagbe town in Benin Republic. The surface water samples were treated with alum, *Moringa oleifera* seeds powder and the combination of alum and *Moringa oleifera* seeds. They are greatly polluted by pathogenic microorganisms such as *Escherichia coli*, *Klebsiella*, *Enterococcus*, *Vibrio*, *Serratia*. The optimal dosages of *Moringa* are 96 mg/L and 80 mg/L respectively. We have observed a reduction of 60% of turbidity and a substantial removal of all pathogenic microorganisms after water treatment with *Moringa oleifera* seeds.

The study done by Sahu and Padhi (2012) revealed that the systematic study on seasonal variation of bacteriological quality of groundwater in selected dug wells, tube wells and bore wells was undertaken in Angul-Talcher industrial cluster of Odisha. The study revealed that bacteriological contamination is predominant on the upper strata and during the rainy season. The analysis results also indicated that water of dug wells was moderately contaminated whereas water of tube wells and bore wells was found comparatively safe for use as drinking water.

Nagalambika and Murthy (2012) used the most probable number (MPN) and membrane filtration techniques (MFT) and Manja's rapid H_2S test for detection of faecal contamination in drinking water. The coliforms bacteria, like *Escherichia coli* were present. Efficiency of H_2S test varies with the source and decreased with the depth of the source of water.

Kofi (2009) conducted the experiment on and Microbiological quality of the surface waters within the Newmont Gold Mines Concession area were assessed for the levels of Total coliforms, faecal coliforms. The results of the study revealed a high microbial indicator counts in all the water bodies suggesting high bacterial pollution of the waters. This was found to have come partly and indirectly from the Mines since the sources of the bacterial contamination could be traced to accidental leakages from the sewage treatment plants (STPs I and II), settlements along these river courses (resettlement villages), population explosion in this mining area with its attendant high waste generation, poor or non-existence sewage system coupled with poor sanitary conditions all contributed immeasurably to the high incidence of bacterial pollution of the water bodies.

MATERIALS AND METHODS

1. MATERIALS AND METHODS

For the present study on ‘Water quality assessment in a textile dyeing industrial area" the material and methods were presented under following headings:

1.1. Study area

1.2. Collection of water samples

1.3. Analysis of water samples

3.3.1.Physical parameters

3.3.2. Chemical parameters

3.4. Microbiological parameters

3.1. STUDY AREA

Madathukulam block of Udumalpet in Tiruppur district was chosen for the present study (Fig.1). Madathukulam is 12 km from Udumalpet, on the way to Palani. The Amaravathi river flows through the town. Udulamlpet is an industrial town with number of textile. Paper and farming related industries. The Amaravathi river and its basin are heavily used for industrial processing water and waste disposal, and as a result are severely polluted.

Textile industry in the study area is raw cotton based. In this type of industries slashing, bleaching, mercerizing and dyeing are the major sources of the wastewater generation. The wastewater contains acid used in desizing, dyeing bases used in scouring and mercerization. It also contains inorganic chlorine compounds for bleaching. Chloride is used as printing ingredients. Organic compounds used are dye stuff, bleachers, finishing chemicals, starch and synthetic polymers for desizing. All these wastes are passed into an effluent tank for primary treatment and then drained into a drainage system.

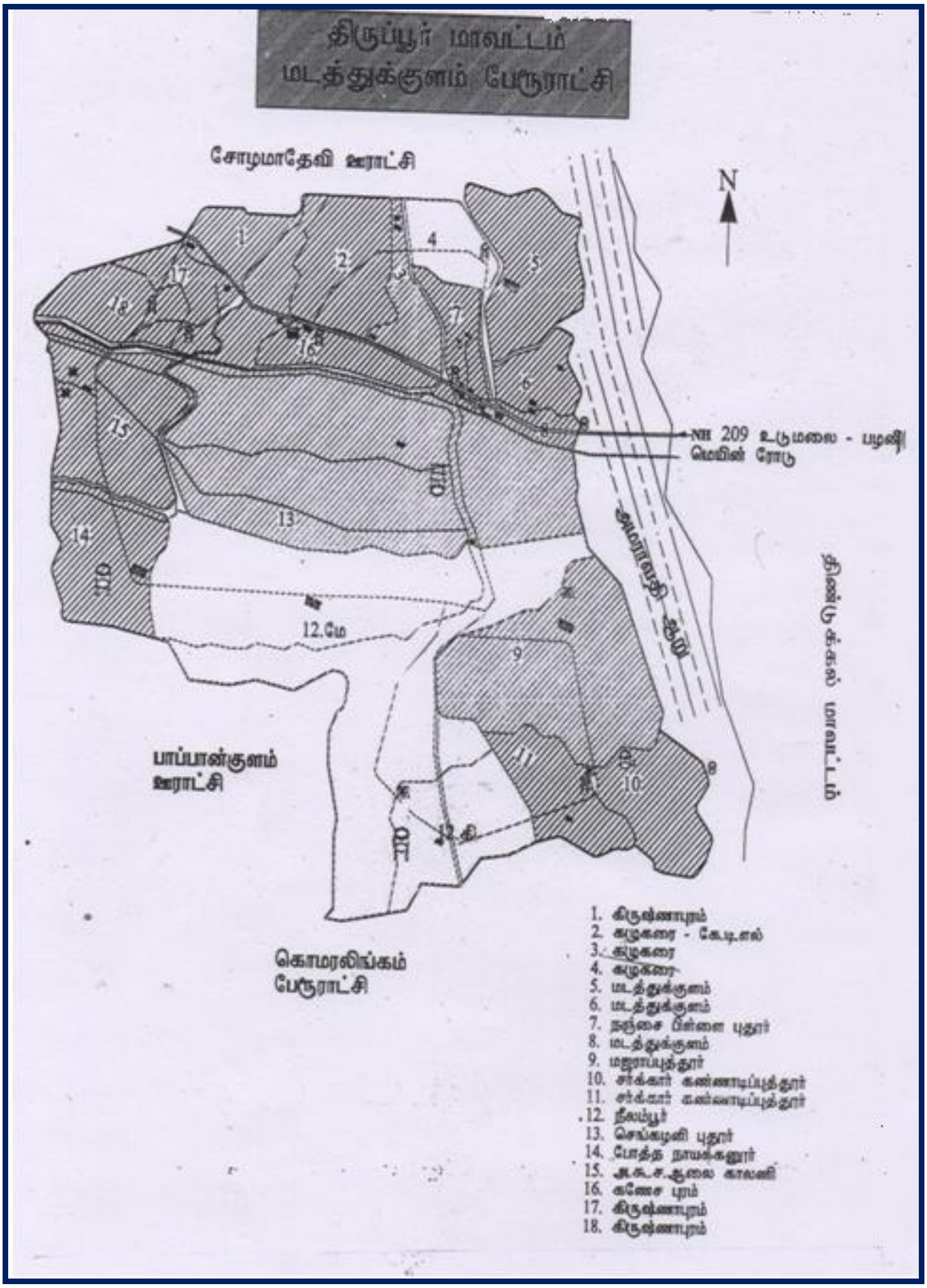

Fig. 1 – Map of Tiruppur District showing Madathukulam block of Udumalpet

3.2. COLLECTION OF WATER SAMPLES

To assess the water quality in the study area surface, ground, tap water samples were collected along with the textile dyeing effluent Amaravathi river flowing through the study area receives effluent discharged by textile industries. The surface water sample was collected from the river, downstream from the point of discharge of the effluent (Fig. 2).

Ground water sample was collected from a bore well in Madathukulam where there is a clustering of textile dyeing and bleaching industries (Fig.3). The effluent sample was collected at the discharge point from where it flows into the river (Fig.4). The tap water is the water from Thirumurthi dam which is supplied for domestic use (Fig.5).

Water samples are collected in clean sterile plastic bottles of 2 litres capacity and stored in a refrigerator at 4º C before they are used for analysis.

3.3. ANALYSIS OF WATER SAMPLES

The physicochemical and microbiological parameters of water samples were analysed. The physicochemical properties were analysed using standard techniques (APHA, 1992).

3.3.1. PHYSICAL PARAMETERS

Colour

The colour of the sample was visually observed.

Odour

The odour of the sample was noted by directly smelling the sample.

Fig. 2 – Collection of river water sample

Fig. 3 – Collection of ground water sample

Fig. 4 – Discharged Dye Effluent in the open drain

Fig. 5 – Collection of tap water sample

Electrical Conductivity

The Electrical Conductivity was estimated using conductivity bridge and expressed in (mmhos/cm).

Temperature

Temperature was measured at the sampling station itself, using mercury filled centigrade thermometer (0º C to 50º C). The readings were made by dipping the thermometer in water for 2 minutes before constant readings were obtained.

Total Suspended Solids

Suspended solids of the sample were estimated by centrifugation method. 50 ml of the sample was centrifuged and after centrifugation the residue was washed with distilled water, recentrifuged and the suspended solids in the centrifuge tube was transferred to a pre weighed silica dish and dried at 105º C. The increase in weight was equal to the amount of suspended solids. The suspended solids present in the sample were calculated by using the formula.

$$\text{Total suspended solids in mg/l} = \frac{\text{Final wt.} - \text{Initial wt. of the crucible}}{\text{Volume of the sample}} \times 1000$$

Total Dissolved Solids

50 ml of the sample was taken in a preweighed silica crucible and the sample was evaporated to dryness using a water bath. After complete evaporation the final weight of the crucible was taken. The total dissolved solids present in the sample was calculated by using the following formula

$$\text{Total dissolved solids in mg/l} = \frac{\text{Final wt.} - \text{Initial wt. of the crucible}}{\text{Volume of the sample}} \times 1000$$

Total Solids

By adding the weight of suspended solids and dissolved solids the amount of total solids was obtained.

3.3.2. CHEMICAL PARAMETERS

pH

A direct reading pH meter was used. The pH meter was first standardized using buffer solutions of pH 7.0 and pH 9.2. The electrodes were rinsed in distilled water and immersed in the water samples and readings were noted in the digital display.

Estimation of Alkalinity

Phenolphthalein alkalinity was estimated by titration method against 0.02N Sulphuric acid, using phenolphthalein as indicator.

After findings phenolphthalein alkalinity, methyl orange alkalinity (total alkalinity) was estimated by continuing the same titration, using methyl orange as indicator.

Calculation

$$\text{Total alkalinity as CaCO3(mg/l)} = \frac{\text{ml of 0.02N } H_2SO_4 \text{ for total alkalinity end point} \times 50 \times 0.02 \times 1000}{\text{ml sample taken for titration}}$$

Estimation of Total Hardness

Total hardness of the sample was estimated by EDTA titrimetric method.

Reagents

Buffer solution

16.9 g of ammonium chloride was dissolved in 143 ml of ammonium hydroxide. 1.179 g of disodium salt of EDTA and 780 mg of magnesium sulphate were added and made upto 250 ml with distilled water.

Inhibitor

4.5g of hydroxylamine hydrochloride in 100ml of 95% ethanol.

Standard EDTA titrant (0.02 N)

3.723g Disodiumethylene diamine tetraacetate dihydrate was dissolved in 1 litre of water. It was standardized against standard calcium solution. 1.0ml of 0.02N EDTA $\equiv$ 1.0 mg of $CaCO_3$.

Eriochrome Black– T indicator

0.5 g of the dye was mixed with 100g of Sodium chloride to obtain a dry powder mixture.

Procedure

- 50 ml of water sample was taken in a conical flask and 2ml of buffer solution and 1ml of the inhibitor were added.
- After adding a pinch of Eriochrome Black– T indicator it was titrated against standard EDTA, till the wine red colour changed into blue. The volume of EDTA used was noted.

Calculation

$$\text{Total Hardness as } CaCO_3 \text{ (mg/l)} = \frac{\text{ml EDTA titant} \times 1 \times 1000}{\text{Volume of sample taken in ml}}$$

Estimation of Calcium Hardness

Reagents

1N sodium hydroxide:

40 g sodium hydroxide was dissolved in 1 litre of distilled water.

Murexide indicator (Ammonium prupurate)

200 mg of the dye was ground with 100 g of sodium chloride.

0.02 N standard EDTA titrant:

3.723 g EDTA disodium salt was dissolved in 1000 ml of distilled water in a volumetric flask.

Procedure

1. 50 ml of water sample was taken in a conical flask and 2 ml of sodium hydroxide was added and pH was adjusted to 12 -13.

2. 0.1 – 0.2 g of the indicator was added and titrated against standard EDTA titrant.

3. The colour change from pink to purple indicated the end point.

Calculation

$$\text{Calcium as } CaCO_3 \text{ (mg/l)} = \frac{\text{ml. EDTA titrant X 1 X 1000}}{\text{ml. sample taken for titration}}$$

Estimation of magnesium hardness

Calculation

Magnesium as $CaCO_3$ (mg/l) = Total hardness – Calcium hardness.

Estimation of Carbondioxide

Reagents

Phenolphthalein indicator solution

500 mg of phenolphthalein was dissolved in 50 ml of ethyl alcohol and 50 ml of distilled water was added.

0.02 N standard sodium hydroxide solution

1N NaOH was prepared by dissolving 40 g of NaOH in 1 litre of CO_2 free distilled water. 20 ml of 1N NaOH was diluted to 1000 ml.

Procedure

- 100 ml of sample was taken in a conical flask and few drops of phenolphthalein indicator was added.

- The solution was colourless and it was titrated against 0.02 N NaOH. (If the colour turns pink free CO_2 is absent).
- End point was the appearance of pale pink colour.

Calculation

$$\text{Carbondioxide (mg/l)} = \frac{\text{ml. alkali used X 1000}}{\text{ml. sample taken}}$$

Dissolved oxygen

Dissolved oxygen of the water sample was estimated by Winkler's method.

Estimation of Biochemical Oxygen Demand (BOD)

Reagents

Phosphate buffer solution

33.4g disodium hydrogen phosphate, 8.5g potassium dihydrogen phosphate, 21.75 g dipotassium hydrogen phosphate, 1.7 g ammonium chloride in 1000 ml of distilled water in a volumetric flask and pH was adjusted to 7.2.

Dilution Water

Double distilled water taken in a glass container was aerated for half an hour using an aerator. 1 ml of phosphate buffer, 1 ml of M_gSO_4 (22.5 g/l) 1 ml of $CaCl_2$ (27.5 g/l) and 1 ml of $FeCl_3$ (0.25 g/l) were added.

Chemicals needed for DO estimation

Procedure

1. Water sample was diluted (measured dilution) with dilution water (Dilution is not necessary for unpolluted waters and seeding is unnecessary for surface waters).

2. Water sample was taken in two BOD bottles. D.O content (D1) of one bottle was analysed and the other was incubated in BOD incubator at 20º C for 5 days.

3. Two other bottles were filled with dilution water D.O content was analysed immediately in one bottle and the other was incubated.

4. D.O was analysed in the incubated water sample (D2) and dilution water after 5 days of incubation.

Calculation

$$\text{BOD (mg/l)} = \frac{(\text{D1} - \text{D2} - \text{BC}) \times 100}{\text{Percentage dilution of sample}}$$

BC – Blank Correction

Estimation of Chemical Oxygen Demand (COD)

Reagents

0.25 N Potassium dichromate

12.259 g of potassium dichromate in 1000 ml of distilled water.

0.1 N Ferrous ammonium sulphate (FAS)

39.2 g of ferrous ammonium sulphate and 20 ml of conc. H_2SO_4 in 1000 ml of distilled water. The solution was standardised with 0.25N potassium dichromate solutions.

Ferroin indicator

1.485 g phenanthroline and 0.695 g ferrous sulphate dissolved in 100 ml distilled water.

Procedure

- 10 ml of sample was taken in a COD flask and 30 ml of conc. H_2SO_4 and 10 ml of 0.25 N potassium dichromate were added.

- The content was refluxed for two hours in a hot plate at 60º C, cooled, diluted with distilled water and made upto 140 ml.
- Two to three drops of ferroin indicator was added and titrated against 0.1 N FAS.
- The colour change from blue green to reddish brown was the end point. The entire procedure was repeated for blank.

COD of the sample was calculated using the formula.

$$\text{COD (mg/l)} = \frac{\text{V X Normality of FAS X 8 X 1000}}{\text{Volume of the sample}}$$

Estimation of Chlorides

The amount of chlorides was estimated by argentometric method.

Reagents

Potassium chromate indicator

25 g of potassium chromate was dissolved in 100 ml of distilled water. Silver nitrate solution was added till a definite precipitate was formed. After 12 hours the solution was filtered and diluted to 500 ml with distilled water.

0.0282 N silver nitrate solution

4.791 g of $AgNO_3$ in 1000 ml of distilled water. The solution was standardised against 0.0282 N sodium chloride.

0.0282 N sodium chloride

1.648 mg of sodium chloride in 1000 ml of distilled water.

Procedure

- 100 ml of sample was taken and pH was adjusted between 7.0 and 8.0.

- 50 ml of this sample was taken and 1 ml of potassium chromate was added.
- The sample was titrated against standard $AgNO_3$ solution taken in a burette until a brick red precipitate was formed and the volume used was noted.

Calculation

$$\text{Chlorides (mg/l)} = \frac{V \times N \text{ of } AgNO_3 \times 35.45 \times 1000}{\text{Volume of the sample}}$$

Estimation of sulphates

Gravimetric method was used for the estimation of sulphate.

Reagents

Methyl red indicator

50 mg methyl red indicator in 50 ml distilled water.

Barium chloride solution

100 g of barium chloride was dissolved in 1000 ml of distilled water and was filtered through Whatmann N0.1 filter paper.

Silver nitrate solution

0.5 ml conc. HNO_3 and 8.5 ml $AgNO_3$ in 500 ml distilled water.

Hydrochloric acid (50%)

Hydrochloric acid and distilled water in 1:1 ratio.

Procedure

- To 100 ml of sample in an Erlenmeyer flask, 2-3 drops of methyl red indicator was added.
- pH was adjusted to about 4.5 to 5.0 by adding Hydrochloric acid until the colour was changed from red to orange. 2 ml of HCl was added in excess.

- The solution was boiled and warm barium chloride was added slowly until the precipitation was completed. The solution was heated in water bath for 2 hours and filtered through Whatman No. 42 filter paper.
- The precipitate was washed with warm distilled water until the filtrate showed no traces of chloride. It was tested by adding $AgNO_3$ solution. Absence of white turbidity on addition of $AgNO_3$ indicated the absence of chlorides.
- The filter paper with precipitate was dried in an oven at 105º C for an hour, and weighed.

Calculation

$$\text{Sulphate (mg/l)} = \frac{\text{Wt. of precipitate in mg. X 0.4116}}{\text{Volume of sample taken}} \text{ X 1000}$$

Estimation of Phosphates

The amount of phosphate was estimated by stannous chloride method.

Reagents

Phenolphthalein indicator solution

500 mg of phenolphthalein was dissolved in 50 ml of ethyl alcohol and 50 ml of distilled water was added.

Sulphuric acid – nitric acid solution

75 ml Conc. H_2SO_4 was added to about 150 ml. distilled water and cooled. 1 ml conc. HNO_3 was added and diluted to 250 ml with distilled water.

Ammonium molybdate solution

2.5 g ammonium molybdate was dissolved in about 200 ml. distilled water.280 ml conc. H_2SO_4 was added to 400 ml distilled water and cooled. Molybdate solution was added to the diluted acid and dilute to 1000 ml.

Stannous chloride solution

2.5 g fresh stannous chloride was dissolved in 100 ml glycerol and heated in a water bath.

Phosphate stock solution

439 mg potassium dihydrogen phosphate was dissolved in distilled water and made up to 1000 ml in a volumetric flask. Two drops of toluene was added as a preservative.

Phosphate standard solution

10 ml phosphate stock solution was pipetted into a 1000ml volumetric flask and made up to the mark with distilled water and should be prepared freshly. 1.0 ml ≡ 1 mg P

Procedure

- 100 ml of the sample was taken in a Nessler tube and 1 drop of phenolphthalein indicator was added. The pink colour developed was destroyed by adding one or two drops of sulphuric – nitric acid solution.

- Phosphate working solution was pipetted in to a series of 100 ml Nessler tubes covering the range up to 20 µg P and made up to 100 ml with distilled water. A Nessler tube containing 100 ml distilled water was kept as a blank.

- To the blank, standards and sample 4 ml ammonium molybdate solution and 0.5 ml stannous chloride solution were added.

- Between 10 – 12 minutes the colour developed was measured at 690nm against the reagent blank using a spectrophotometer.

- A calibration curve was prepared and amount of phosphate equivalent to the observed optical density was calculated and the result was expressed as mg phosphate per litre of sample.

Estimation of Fluorides

Reagents

Alizarin red solution (Solution A)

0.7 g alizarin red in 100 ml distilled water.

Zirconyl acid solution(Solution B)

0.45 g zirconyl chloride in 100 ml distilled water.

Sulphuric acid solution (Solution C)

70 ml conc. H_2SO_4 in 700 ml of distilled water.

Acid zirconium-alizarin solution

Solution A was poured into solution B, solution C was added, made upto 1000 ml, stored in dark and used after 24 hours.

Fluoride stock solution

221.0 mg anhydrous sodium fluoride in 1000 ml distilled water.

Fluoride standard solution

100 ml stock solution diluted to 1000 ml with distilled water.

Procedure

- 50 ml of the sample was taken in a 50 ml Nessler tube.
- 1.0, 2.0, 4.0, 6.0, 8.0,10.0, 12.0 ml of the standard fluoride solution were taken in 50 ml Nessler tubes and the volume was made upto 50 ml with distilled water.
- 50 ml of distilled water was taken as blank.

- 1.0 ml of acid zirconium-alizarin solution was added to standards, blank and the sample, well mixed and incubated for 20 minutes at room temperature.
- The reading was taken in a calorimeter at 540 nm wavelength.
- A standard curve was prepared by plotting fluoride concentrations of standard solutions of the X-axis and optical density on the Y-axis.
- Fluoride content of sample was found out by matching its absorbance with the standard curve and the result was expressed in mg/l.

Estimation of Nitrates

Reagents

Nitrate stock solution

722 mg potassium nitrate was dissolved in distilled water and made up to 1000 ml in a volumetric flask.

Nitrate standard solution

100 ml nitrate stock solution was pipetted in to a 1000 ml volumetric flask and made up to the mark with distilled water.

Brucine – Sulphanilic acid solution

1 g brucine sulphate and 100 mg sulphanilic acid was dissolved in 70 ml hot distilled water 3 ml conc. HCl was added cooled and diluted to 100 ml with distilled water.

Sulphuric acid solution

500 ml conc. H_2SO_4 was added to 75 ml distilled water and cooled to room temperature.

Procedure

- 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5 and 5.0 ml of nitrate standard solution were taken in a series of 50 ml beakers and diluted to 5 ml with distilled water.
- A beaker containing 5 ml of distilled water was used as a blank.
- 2 ml of the sample was taken in a 50 ml beaker and diluted to 5 ml with distilled water. 1 ml of brucine sulphanilic acid solution was added to the blank, standards and sample are mixed well.
- 10 ml of Sulphuric acid solution was taken in a second series of 50 ml beakers. The contents of the first series of beakers were poured in to each of the second series of beakers and mixed well. Beakers were kept in the dark for 10 minutes.
- 10 ml of distilled water was added to all the beakers. Beakers were allowed to cool for 20 – 30 minutes. The colour development was read in a colorimeter against 510 nm. Using the calibration curve the mg. equivalent of nitrate nitrogen in the sample was found out.

Calculation

$$\text{Nitrate (mg/l)} = \frac{\text{mg. Nitrate X 1000}}{\text{ml. sample taken for estimation}}$$

Estimation of nickel

The amount of nickel was estimated by dimethyl glyoxime method

Reagents

Nickel stock solution

447.9 mg Nickel sulfate (NiSO4.6H2O) was dissolved in distilled water and the volume was made upto 1000 ml. in volumetric water (1.00 ml = 100µg Ni).

Nickel working solution

10.0 ml of nickel stock solution was pipetted into a 100 ml volumetric flask and made upto the mark with distilled water (1.00 ml = 10 µg Ni).

0.5N Hydrochloric acid

50ml conc. HCl was diluted to 1000 ml with distilled water

Sodium citrate solution

125g sodium citrate was dissolved in 500 ml distilled water.

0.05 N Iodine solution

20g potassium iodide, was dissolved in 5 ml. distilled water. 6.4 g iodine was dissolved in this solution, and the solution was diluted to 1000 ml.

Dimethyl glyoxime solution

1g dimethyl glyoxime was dissolved in 100 ml of concentrated ammonia solution. 100 ml distilled water was added and filtered if necessary.

Additional reagents for the removal of interferences

Dilute ammonia solution - 10 ml. concentrated ammonia solution was diluted to 500ml with distilled water.

Chloroform

Procedure

1) Appropriate volumes of nickel working solution covering the range up to 100 μg was taken in a series of 50ml Nessler tubes. 50 ml Nessler tube with distilled water was kept as the blank.

2) A suitable aliquot of the neutralised (acid digested sample containing not more than 100 μg nickel) was taken in a 50ml Nessler tube.

3) To the blank, standards and sample 20 ml of 0.5 N. HCl was added.

4) Then following reagents were added in order with mixing after each addition:

   (i) 10 ml. sodium citrate solution

   (ii) 2 ml. iodine solution,   and

   (iii) 4 ml. dimethyl glyoxime solution

5) The volume in all the flasks were made upto 50 ml. with distilled water and allowed to stand for 20 minutes.

6) Optical density was measured in a spectrophotometer at 470 nm against the reagent blank. A calibration curve was prepared and the microgram of nickel equivalent to the observed optical density was determined.

The result was expressed as mg nickel per litre of the sample.

3.4. MICROBIOLOGICAL PARAMETERS

3.4.1. Detection of coliform bacteria

The three basic tests to detect coliform bacteria in water are presumptive, confirmed, and completed tests. The tests are performed sequentially on each sample under analysis. They detect the presence of coliform bacteria (indicators of fecal contamination), the gram-negative, non-spore-forming bacilli that ferment lactose with the production of acid and gas that is detectable following a 24-hour incubation period at 37º C.

Presumptive Test

Determination of the Most Probable Number of Coliform Bacteria

Purposes

- To determine the presence of coliform bacteria in a water sample.
- To obtain some index as to the possible number of organisms present in the sample under analysis.

Principle

The presumptive test is specific for detection of coliform bacteria. Measured aliquots of the water to be tested are added to a lactose fermentation broth containing an inverted gas vial. Because these bacteria are capable of using lactose as a carbon source (the other enteric organisms are not), their detection is facilitated by use of this medium. In addition to lactose, the medium also contains a surface-tension depressant the bile salt, which suppresses the growth of organisms other than coliform bacteria.

Tubes of this lactose medium are inoculated with 10-ml, 1-ml and 0.1-ml aliquots of the water sample. The series consists of at least three groups, each composed of three tubes of the specified medium. The tubes in each group are then inoculated with the designated volume of the water sample as described under “Procedure”. The greater the number of tubes per group, the greater the sensitivity of the test. Development of gas in any of the tubes is *presumptive* evidence of the presence of coliform bacteria in the sample. The presumptive test also enables the microbiologist to obtain some idea of the number of coliform organisms present by means of the most probable number test (MPN). The MPN is estimated by determining the number of tubes in each group that show gas following the incubation period (Table - 1).

Procedure

Three separate series of test tubes each consisting of three groups and a total of nine tubes per series were kept in a test tube rack. Each test tube was labeled indicating the water source and the volume of the sample inoculated. This set up was presented in the below table.

10 ml aliquots of water sample were transferred to the three tubes labeled LB2X – 10 ml. 1 ml aliquots of water sample were transferred to the three tubes labeled LB1X – ml 0.1 ml aliquots of water sample were transferred to the three tubes labeled LBX – 0.1 ml. All the tubes were incubated for 48 hours at 37º C.

Series 1: Sample 1	3 tubes of LB2X – 10 ml 3 tubes of LB1X – 1 ml 3 tubes of LB1X – 0.1 ml
Series 2: Sample 2	3 tubes of LB2X – 10 ml 3 tubes of LB1X – 1 ml 3 tubes of LB1X – 0.1 ml
Series 3: Sample 3	3 tubes of LB2X – 10 ml 3 tubes of LB1X – 1 ml 3 tubes of LB1X – 0.1 ml

LB2X – double strength lactose fermentation broth.

LB1X – single strength lactose fermentation broth.

Water samples were mixed by shaking thoroughly.

Confirmed test

Purpose

To confirm the presence of coliform bacteria in a water sample for which the presumptive test was positive**.**

Principle

The presence of a positive or doubtful presumptive test immediately suggests that the water sample is nonpotable. Confirmation of these results in necessary, since positive presumptive tests may be the result of organisms of non coliform origin that are not recognized as indicators of fecal pollution.

The confirmed test requires that selective and differential media such as eosin-methylene blue (EMB) or endo agar be streaked from a positive lactose broth tube obtained from the presumptive test. Eosin-methylene blue contains the dye methylene blue, which inhibits the growth of gram-positive organisms. In the presence of an acid environment, EMB forms a complex that precipitates out on the coliform colonies, producing dark centers and a green metallic sheen. This reaction is characteristic for *Escherichia coli,* the major indicator of fecal pollution. Endo agar is a nutrient medium containing the dye fuchsin, which is present in the decolorized state. In the presence of acid produced by the coliform bacteria, fuchsin forms a dark pink complex that turns the *E. coli* colonies and the surrounding medium pink.

Procedure

The covers of three EMB plates were labelled as Sample 1, Sample 2 and Sample 3. The surface of each EMB plate was streaked using a positive 24 hour lactose broth culture from the presumptive test obtained for the corresponding water sample. The three plate cultures were incubated in an inverted position for 24 hours at 37º C.

Table - 1

MPN Determination from Multiple -Tube Test

Number of Tubes Giving Positive Reaction out of			MPN Index per 100 ml
3 of 10 ml Each	3 of 1 ml Each	3 of 0.1 Each	
0	0	1	3
0	1	0	3
1	0	0	4
1	0	1	7
1	1	0	7
1	1	1	11
1	2	0	11
2	0	0	9
2	0	1	14
2	1	0	15
2	1	1	20
2	2	0	21
2	2	1	28
3	0	0	23
3	0	1	39
3	0	2	64
3	1	0	43
3	1	1	75
3	1	2	120
3	2	0	93
3	2	1	150
3	2	2	210
3	3	0	240
3	3	1	460
3	3	2	1100

Completed test

Purpose

To confirm the presence of coliform bacteria in a water sample, or, if necessary, to confirm a suspicious but doubtful result of the previous test.

Principle

The completed test is the final analysis of the water sample. It is used to examine the coliform colonies that appeared on the EMB or endo agar plates used in the confirmed test. An isolated colony is picked from the confirmatory test plate and inoculated into a tube of lactose broth and streaked on a nutrient agar slant to perform a Gram stain. Following inoculation and incubation, tubes showing acid and gas in the lactose broth and the presence of Gram-negative bacilli on microscopic examination lead to further confirmation of the presence of *E.coli* and they are indicative of a positive completed test.

Procedure

One lactose broth tube and one nutrient agar slant were inoculated with the same isolated *E.coli* colony obtained from the EMB agar medium. Similarly another set up was inoculated with the same isolated *E.coli* colonies obtained from the EMB agar medium of the corresponding water sample. The tubes and agar slants of the three water samples were incubated for 24 hours at 37º C.

3.4.2. Enumeration of bacterial populations by plate count technique

1 ml of the water sample was taken in a 250 ml conical flask containing 100 ml of sterilized distilled water to give a 1:100 dilution. It was then diluted till the original sample was diluted to 10^{-8} times (10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7}, 10^{-8}). From the appropriate dilutions 1 ml of the sample was transferred to sterile petriplates and three petriplates

were used for each dilution. 20 ml of nutrient agar medium melted and cooled to 45º C was added to each petriplate the contents were mixed by rotating gently to distribute the cells through out the medium. The plates were allowed to solidify and were incubated in inverted position for 24 hour at 37º C. The colony forming units (CFU) per ml of water sample was calculated.

$$\text{CFU / ml. of water sample} = \frac{\text{No. of colonies (Average of three replicates)}}{\text{Sample volume}} \times \text{Dilution factor}$$

3.4.3. Isolation and identification of bacterial colonies

The bacterial colonies were isolated by serial dilution technique. 1 ml of the sample was serially diluted and different dilutions were plated on nutrient agar and incubated at 37º C for 24 hours. The well grown colonies were picked up and stored in nutrient agar slants at 4º C. The purified bacterial cultures were identified based on Gram staining and use of selective medium–EMB agar medium and starch agar medium.

3.4.4. Enumeration of fungal populations by plate count technique

1 ml of the water sample was taken in a 250 ml conical flask containing 100 ml of sterilized distilled water to give a 1:100 dilution. It was then diluted till the original sample was diluted to 10^{-8} times (10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7}, 10^{-8}). From the appropriate dilutions 1 ml of the sample was transferred to sterile petriplates and three petriplates were used for each dilution. 20 ml of rose bengal chloramphenicol agar medium melted and cooled to 45º C was added to each petriplate and the contents were mixed by rotating gently to distribute the cells through out the medium. The plates were allowed

to solidify and were incubated at room temperature for 5 days. The colony forming unit (CFU) per ml of water sample was calculated

$$\text{CFU / ml. of water sample} = \frac{\text{No. of colonies (Average of three replicates)}}{\text{Sample volume}} \times \text{Dilution factor}$$

3.4.5. Isolation and identification of fungal colonies

The fungal colonies were isolated by serial dilution technique. 1 ml of the sample was serially diluted and different dilutions were plated on rose bengal chloramphenicol agar medium and incubated at 28º C for 5 days. The well-grown colonies were picked up and stored in rose bengal chloramphenicol agar slants at 4º C. The purified fungal colonies were identified based on Lactophenol cotton blue staining.

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

Water is the elixir of life. Adequate supply of safe potable water is absolutely essential and is the basic need for all human beings on the earth. Due to rapid industrialization and subsequent contamination of surface water and ground water sources water conservation and water quality management has now-a-days assumed a very complex shape (Palanisamy *et al.,* 2007). Attention on water contamination and its management has become the need of the hour because of its for reaching impact on human health.

One of the main sources with severe pollution problems worldwide is the textile industries and its dye – containing wastewaters. 10 – 25% of textile dyes are lost during the dyeing process, and 2.20% is discharged as aqueous effluents in different environmental components.

Globally, the discharge of effluents into water bodies with improper water management practices contributes significantly to water pollution problems. The water quality is deteriorated in industrialized as well as developing countries. More than half of the world's major rivers are contaminated, which are polluting surrounding ecosystems, deteriorating the ground water quality and creating a risk for human health (Ananthi *et al*., 2004).

Tiruppur district in Tamil Nadu is known as the textile city of India. The garment export from Tiruppur touched US $2500 million in the year 2008 – 2009 (Srivasta *et al*., 2011). More than 100000 m^3 / day of textile effluent was generated form 800 dyeing, bleaching and textile processing industries situated in Tiruppur (Ranganathan *et al*., 2007).

Hence, the present investigation was carried out to assess water quality of surface and ground water in a textile dyeing industrial area of Tirupur district.

CHARACTERISATION OF THE TEXTILE EFFLUENT

The physicochemical characteristics of the textile effluent after primary treatment were depicted in Table 2. The effluent sample from dyeing and bleaching industries in Madathukulam of Udumalpet was characterized for their pollution potential.

Physical Parameters

Effluent sample was dark yellow in colour with objectionable odour. The electrical conductivity was high (7218 μmho/cm). The sample recorded high levels of solids. The total solids (TS) total suspended solids (TSS) and total dissolved solids (TDS) were 8000 and 2000 and 6000 mg/L respectively.

Colour of the effluent depends on the dyes used. Different colour marks are used for dyeing different lots of cloth. Both synthetic and natural colours easily disperse in water

High conductivity indicates the presence of sufficient ions in the effluent and suggests that the effluents could be treated by physic chemical method of coagulation and flocculation. High Electric conductivity (EC) is due to the presence of high amount of dissolved salts (Prakash and Sonashekar, 2006).

Chemical Parameters

The effluent showed a pH of 9.0 and a total alkalinity of 920 mg/L. Total hardness recorded was 406 mg/L and the concentration of calcium and magnesium were 62 and 28 mg/L respectively.

Dissolved oxygen (DO) content was 2.0 mg/L BOD was 220 mg/L and COD was 411 mg/L.

The amount of chlorides, sulphates and nitrates were 2299, 481 and 60 mg/L respectively. Phosphates and fluorides were absent. The amount of nickel in the sample was almost negligible (0.02 mg/L).

The effluent sample was more alkaline pH is a valuable index in judging the nature and intensity of pollution of wastewater. It is a major factor which allows certain impurities to get precipitated or to remain free in the effluent. Highly alkaline pH is due to the presence of bases. Total alkalinity has been reported as a major factor which influences pH (Wetzel, 1972 and Verma and Deleta, 1975). Alkalinity in the capacity of water to neutralize acid and is characterized by the present hydroxyl ions.

Total hardness and the amount of calcium and magnesium recorded were low. Their low concentration in the wastewater may be due to the use of soft water in the dyeing and printing process to avoid coagulation of dyes (Hussain and Hussain, 2012).

Oxygen demand of the effluent was quite high and the DO content was very low. This indicates that the effluent is high in recalcitrants and hardly degradable compounds which may not undergo more than 50% substrate biodegradation. It is known that organic matter with 50 – 90% substrate biodegradation has a COD : BOD ratio between 2 and 3.5 .

Most of the industrial effluents have low DO values, below 3 mg/L. The DO level of effluents increases with distance,, which may be due to long contact time and large surface area for exposure for the adsorption of atmospheric oxygen (Ishaq *et al*., 2013).

The effluent sample recorded high amounts of chlorides. High chloride content may be due to water softening process or sodium chloride is used to recharge softterns. Similarly sulphates in wastewater may be due to use of sulphuric acid in various steps of dyeing and printing process.

The results of the physicochemical analysis show that the textile effluent is characterized by the presence of Colour, objectionable odour, high electrical conductivity, high TDS values, high BOD and COD, low DO, high amounts of chlorides and sulphates.

SURFACE AND GROUNDWATER CONTAMINATION

To assess the impact of wastewater of textile dyeing and bleaching industries on water quality, surface and groundwater samples were analyzed for their physicochemical properties and microbial contamination.

Surface water contamination

Physicochemical results of river water sample were presented in Table 2 and table 3.

The water sample collected from the area was found to be colourless and odourless. The temperature observed was 30ºC. The EC of the sample was found to be 1190µmho/cm. The total solids (TS) estimated amounted to 2005 mg/l. The sample had 800 mg/L of TSS and 1700 mg/L of TDS.

The pH recorded was 7.9 and the alkalinity of the sample was 160 mg/l. The amount of calcium, magnesium and total hardness were found to be 260 mg/l, 220 mg/l , and 400 mg/l respectively.

The concentration of dissolved oxygen was 4.1 mg/L. BOD and COD were 110 mg/l and 156 mg/l respectively.

The chlorides and sulphates were 989.9 mg/l, 0.41 mg/l respectively. Phosphate content was nil. The fluoride concentration was below the dedectable limit. Nitrate content was 0.01 mg/l.

The water sample was free from nickel content.

Tap water analysis

Tap water is the water from Thirumurthy dam on Amaravathi river, supplied for domestic uses which is almost free from anthropogenic activities. A comparison of water quality parameters of tap and river water samples was made to assess the pollution load of the river water in the study area where it is receiving effluents from textile industries.

The water sample was colourless and odourless and the temperature observed was 30ºC.

The EC of the sample was 310µmho/cm. The TSS, TDS and TS of the sample were found to be 102, 410 and 512 mg/l respectively. The pH of the sample was 7.0 and the alkalinity was 46mg/l. Calcium, magnesium and total hardness estimated were 100 mg/l, 60 mg/l and 190 mg/l respectively.

The amount of dissolved oxygen was 6.0 mg/l. BOD of the sample was 1.4 mg/l and COD of the sample was 3.0 mg/l.

The concentration of chlorides and sulphates were 69.9 mg/l, 0.16 mg/l respectively. The phosphate content was nil. The fluoride concentration was below the dedectable limit. The nitrate nitrogen was 0.01 mg/l

From the comparative study it is clear that the following parameters of river water showed a marked change. EC, TDS values were much higher pH was slightly alkaline. Total alkalinity showed a slight increase.

DO was low, BOD and COD values were very high. Chlorides showed a maximum increase (Fig. 6).

Thus the physicochemical properties of river water are getting altered by the effluent flow into the river. The pollution load may still increase as the river passes through Karur town, another major textile city in Tamil Nadu.

Ground water contamination

Physicochemical parameters of ground water samples were presented in Table 2 and Table 3 respectively.

The water sample from the area was found to be colourless and odourless. The temperature recorded at the time of collection was 30^{0}c.

The EC of the sample was found to be 1081 µmho/cm. Total solids (TS) estimated amounted to 2005 mg/l; total dissolved solids (TDS) was found to be 1705 . The water sample contained 295mg/l of suspended solids.

The pH noted was 7.1. The alkalinity observed was 124 mg/l. Total hardness estimated was 604 mg/l. The amount of calcium and magnesium were found to be 212 mg/l and 104 mg/l respectively.

Dissolved oxygen content was 3.5 mg/l. BOD and COD were 16.6 mg/l and 304 mg/l respectively.

The amount of chlorides, sulphates was 999.5 mg/l, 0.74 mg/l respectively. Phosphates were nil. The fluoride content was below detectable limit (BDL). The amount of nitrate nitrogen was 0.02 mg/l. Nickel concentration was found to be nil.

Table 4 shows the ISO limits for the drinking water.

Table 2

Comparison of physical parameters of water samples

S. No	Parameters	Surface Water sample	Tap water sample	Ground Water sample	Effluent sample
1	Colour	Colourless	Colourless	Colourless	Dark yellow colour
2	Odour	Odourless	Odourless	Odourless	Objectionable odour
3	Electrical conductivity (EC) µmho/cm	1190	310	1081	7218
4	Temperature (ºC)	30º C	30 º C	30º C	32º C
5	Total Suspended Solids (mg/l)	8000	102	295	2000
6	Total Dissolved Solids (mg/l)	1700	410	1705	6000
7	Total Solids (mg/l)	2500	512	2005	8000

Table 3

Comparison of chemical parameters of water samples

S. No	Parameters	Surface Water sample	Tap water sample	Ground Water sample	Effluent sample
1	pH	7.9	7.0	7.1	9.0
2	Alkalinity	160	46	124	920
3	Total hardness	400	190	604	406
4	Calcium	260	100	212	62
5	Magnesium	220	60	104	28
6	Dissolved oxygen	4.1	6.0	3.5	2.0
7	BOD	110	1.4	16.6	220
8	COD	156	3.0	304	411
9	Chlorides	987.9	69.9	999.5	2299
10	Sulphates	0.41	0.16	0.74	481
11	Phosphates	Nil	Nil	Nil	Nil
12	Fluorides	BDL	BDL	BDL	Nil
13	Nitrate nitrogen	0.01	0.01	0.02	60
14	Nickel	Nil	Nil	Nil	0.02

All the values except pH are in mg/l

Table 4

Classification of Groundwater for drinking purpose as per IS:10500, 1991

S.No	Parameter	Maximum Desirable Limit	Maximum Permissible Limit
1	pH	6.5-8.5	6.5-8.5
2	Total Dissolved Solids	500	2000
3	Alkalinity	200	600
4	Chloride	250	1000
5	Sulphate	200	400
6	Nitrate	45	100
7	Fluoride	1.0	1.5
8	Total Hardness	300	600
9	Calcium	75	200
10	Magnesium	30	100
11	Copper	0.05	1.5
12	Chromium	0.05	0.05
13	Iron	0.3	1.0

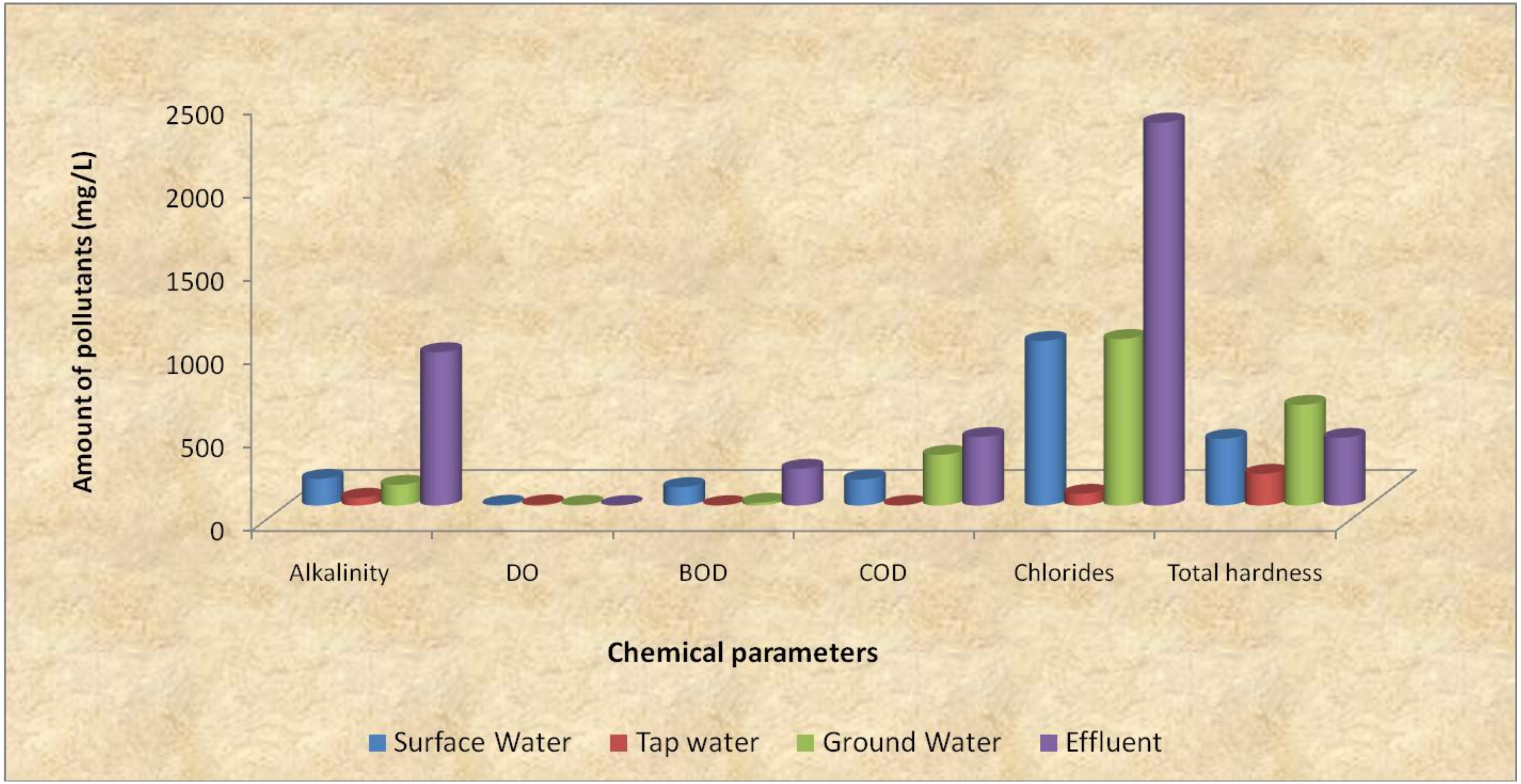

Fig. 6 - Comparison of selected parameters of tap and river water

WATER QUALITY PARAMETERS

Colour

Colour is a common constituent of natural water. The determination of colour is rapid and is useful in detecting a change in the character of the water. Colour is removed to make water suitable for general and industrial applications.

Odour

In its pure form water cannot produce odour or taste sensations. Most organic and inorganic chemicals contribute taste or odour. These chemicals may originate from municipal and industrial waste discharges, from natural sources such as decomposition of vegetable matter or from associated microbial activity.

The usual requirement of water sample is that they should not contain any objectionable odour.

Electrical Conductivity (EC)

Electrical conductivity is a measure of water's capacity to conduct electric current. Generally, ground water tends to leave high EC than surface water due to the presence at high amount of dissolved salts (Prakash *et al.,* 2006).

Total solids

The first effect of organic pollution is an immediate rise in the concentration of various solids. The pollution has a direct relationship with the dissolved solids (Verma *et al.,* 1977 and Prasad and Saxena, 1980).

pH and alkalinity

pH is a measure of the intensity of acidity or alkalinity and depends on the concentration of hydrogen icons in water. pH value below 4 produces sour taste and a higher value above 8.5 give alkaline taste (Patil and Patil, 2010). Water with pH value of about 10 are exceptional and reflects contamination by strong base as $Ca(OH)_2$.

The low and high hydrogen ion concentrations in the water bodies can be natural as well as anthropogenic (Beamish and Harvey, 1972). According to Dahl (1927) both acidic and alkaline waters are stressful environment for aquatic animals.

pH has no direct effect on health but it alters the taste of water. Prasad *et al.* (1985) attributed higher value of total alkalinity to polluted condition of water.

Hardness

The hardness is the soap destroying power of water. The carbonated hardness is the temporary hardness and is mainly due to the presence of bicarbonates of calcium and magnesium. The non carbonate hardness is the permanent hardness and is due to the presence of sulphates, chlorides and nitrates of calcium and magnesium.

Classification of lentic water based on hardness suggests that if the hardness is more than 250 mg/L the water is considered to be very hard.

The hardness of water is not a pollution parameter but indicates water quality, mainly in terms of Ca^{2+} and Mg^{2+}, expressed as $CaCO_3$.

D.O. Content

The measurement of D.O indicates immediately the purity of water or waste water. Depleted dissolved oxygen content is more significant in metal pollution (Khillare and Snowane, 1990). Low D.O confirms pollution due to addition of wastes (Trivedy *et al.,* 1990).

Low D.O content due to decomposition of organic matter was reported by Das and Verma, 1993. Dissolved oxygen levels in water bodies indicate its ability to support aquatic fauna. The high DO in water indicates that the rate of oxygen replenishment in water is greater than, the oxygen utilization and is necessary for good water quality, dissolved oxygen levels between 5.0 and 8.0 mg/L are satisfactory for survival and growth of organism.

BOD and COD

Organic pollutants, which are susceptible to oxidation by strong chemicals, are measured in the form of chemical oxygen demand and those are susceptible to oxidation by biological matter are measured in the form of biological oxygen demand. These tests help in the estimation of organic load in industrial or any kind of waste water, which contains material toxic to biological realm

High BOD means that there is less of oxygen to support life and indicates organic pollution. Higher BOD values in sewage polluted water bodies may be probably due to higher organic load and higher growth of total micro-organisms. The high values of BOD and COD reveal that the water is polluted considerably (Roshan *et al.,* 1992).

Chlorides

The chloride content in the natural water appears to be mainly due to sewage discharge and their principal sources are drains rich in animal refuse. Trivedi (1978) reported that even moderate level of chlorides causes sufficient water pollution and higher concentration indicates pollution due to sewage as well as industrial waste. According Kenwood (1920), Tresh et al. (1944) and Ganapthi (1962) the chloride content oif the water was due to pollution.

Water Quality Assessment

Rural community mainly depends on ground water for their domestic use, because ground water is more trusted then surface water. Ground water is highly valued because of certain properties not possessed by surface water (Jammeel and Sirajudeen, 2006).

Various standards are used to find out the suitability of ground water for drinking. Their limits for safe drinking water are different as the limits depend on the environmental condition because water consumption per day is directly related to it. Hence the Indian standard IS:10500, 1991 are used for comparing the results. Bureaus of Indian standards have proposed two limits for drinking purpose, the maximum desirable limit and maximum permissible limits in their standards. Maximum desirable limit is best for consumer but in its absence of such water source maximum permissible limit may also be used. Table – represents classification based on IS:10500, 1991.

The study revealed that the water quality parameters pH and Alkalinity are within the maximum desirable limit and the other parameters. TDS, total hardness, chlorides, sulphates, nitrates and fluorides are within the maximum permissible limit, prescribed for ground water for drinking purpose. Therefore, it is concluded that the ground water in the study area is quiet safe for drinking.

Conclusion

The study addresses the physicochemical characteristics of the textile effluent and warrants remedial measures to safe guard the environment.

It is recommended that the disposal of industrial waste water without proper treatment should be discouraged and continuous monitoring of water quality is imperative to ensure the protection of water resources from further degradation.

MICROBIAL CONTAMINATION

The ground and river water sample gave positive results for bacterial and fungal contamination. They showed negative results for the presence of coliform bacteria.

Detection of coliform bacteria

The MPN for the coliform bacteria for the three water samples were found to be nil.

Enumeration of bacterial population and their identification

The number of colony forming units per ml of ground water and surface water were found to be 28 X 10^7, nil, 37 X 10^7 respectively. The tap water showed the absence of bacteria. The major bacterial colonies isolated and identified were *Micrococcus luteus* and *Bacillus subtilis*.

Description of the bacterial colonies

Micrococcus luteus

They appear as yellow colonies when grown on nutrient agar. It belongs to the genus Micrococcus and family Microcaccaceae. It occurs in a wide range of environments including water, dust and soil. They are gram positive spherical cells of about 0.5 to 3 micrometer in diameter and typically appear in tetrads. It is not a spore former, but can survive for an extended period of time (Figure 7a).

Bacillus subtilis

The colony develops on the starch agar medium. It produces amylase enzyme which digests starch. When iodine solution is added to the medium a colourless zone appears around the colony whereas the medium develops a blue colour (Fig 7b).

Fig 7a. ***Micrococcus luteus*** **on nutrient agar medium**

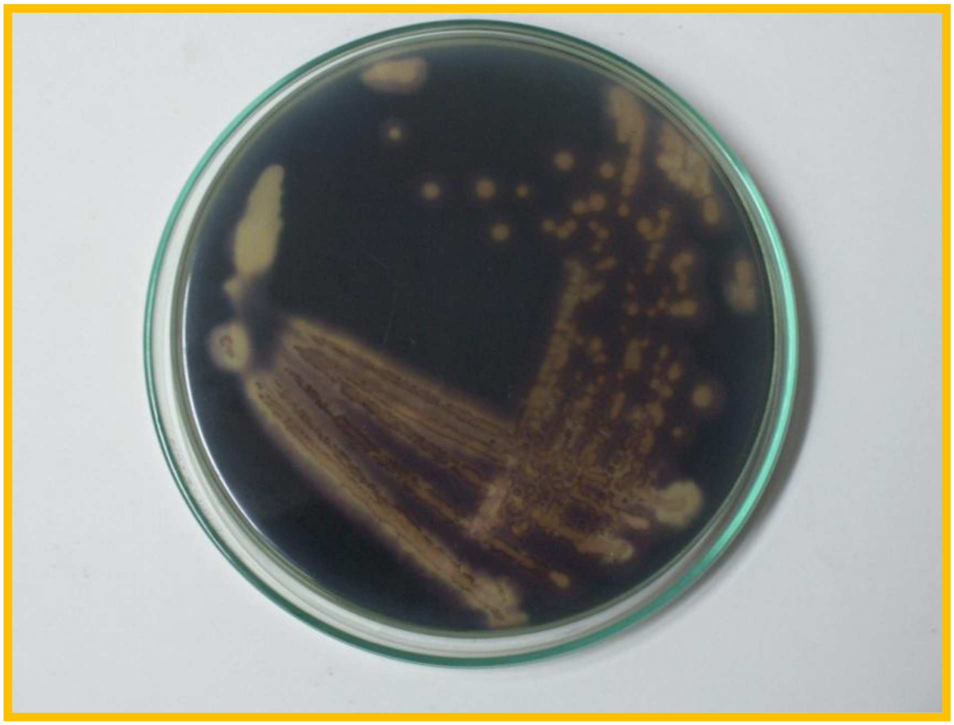

Fig 7b. ***Bacillus subtilis*** **on starch agar (Iodine test)**

4.3. Enumeration of fungal population and their identification

The number of colony forming units per ml of the ground water was estimated to be 8 X 10^3, nil for tap water and 17 X 10^3 for river water. Major fungal colonies isolated were *Aspergillus flavus, Fusarium, Rhizopus* and *Cladosporium*.

Description of the fungal colonies

Aspergillus flavus

1. It is a common mold in the environment.
2. Colonies on Rose Bengal agar are yellow – green in colour.
3. It is predominately a saprophyte and grows on dead plant and animal tissue in the soil.
4. It grows by producing thread like branching filaments known as hyphae.
5. It produces a distinctive conidiophore composed of a long stalk supporting an inflated vesicle.
6. Conidiogenous cells on the vesicle produce the conidia.
7. A network of hyphae known as the mycelium secretes enzymes that break down complex food source.
8. They produce conidiospores (asexual spores)
9. The food molecules are absorbed by the mycelium to fuel additional fungal growth. Many strains produce significant quantities of aflatoxin which is an acutely toxic and carcinogenic compound (Fig 8a).

Fusarium

1. It belongs to the class Deuteromycetes. Colonies cottony, slow or fast growing they are of varying colours. (e) white, pink etc.
2. Conidiophores are short, branched, bearing conidia
3. Fruiting layer floccose, hyaline, white to rose coloured, richly branched.
4. The conidial terminal was of two types, the microconidia and macro conidia. Micro conidia are simple and pear shaped, kidney shaped macro conidia are sickle – shaped (ie fusiform) and many – celled (1-5 or 7).
5. Important species are *F. udum, F. solani, F. cubense, F.semitectum* etc. (Figure 8b)

Cladosporium

1. It belongs to the class hyphomycetes.
2. Colonies effuse or occasionally punctiform, often olivaceous but also sometimes grey, buff, brown or dark blackish brown, velvety, flucose or hairy
3. Stroma sometimes present setae and hyphopodia absent
4. Conidiophores macro nematous or semi macro nematous macronematous conidiophores straight. Mostly unbranched or with branches restricted to the apical region forming a stipe and head, olivaceous brown.
5. Conidia catenate as a rule but sometimes solitary especially inspecies with large conidia. Often in branched chains, simple fusiform, ovoid etc. (Fig 8c).

Rhizopus

1. It belongs to the class zygomycetes

2. Well developed, richly branched and rapidly growing mycelium
3. Hyphae are coenocytic (containing many nuclei, no septa present)
4. Septation occurs only during unfavourable conditions and in special parts of mycelium.
5. Two types of mycelia present, submerged mycelia in substratum and the aerial mycelia. The aerial mycelia form stolon ie. the arcing filaments
6. Rhizoids arise from the nodes and later implanted into substratum.
7. Sporangiophores also arise aerially from the nodes either singly or in groups of two, three or more.
8. At the tip of sporangiophores, spherical sporangia are borne enclosing the hemispherical columella.
9. At maturity sporangia are black in colour and bear numerous spores. Spores are round or oval, angular, colourless to bluish or brownish. Spores longitudinally striated (Fig 8d).

The study reflected the microbial contamination of the investigated river and ground water samples. River and ground water samples showed bacterial and fungal contamination and no coliform were detected.

Fig. 8a *Aspergillus flavus*

Fig. 8b *Fusarium*

Fig. 8c *Cladosporium*

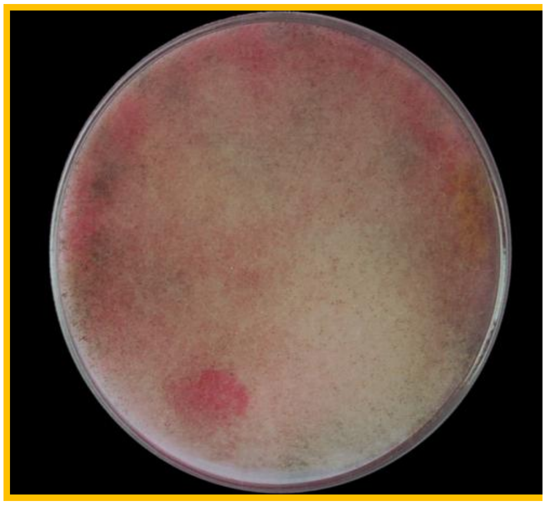

Fig. 8d *Rhizopus*

Bacterial contamination

M. luteus detected in the sample is a commonly occuring soil bacterium and its occurrence in ground and river water is a natural phenomenon.

Fungal contamination

The fungi detected in the samples normally occur in soil and may contribute to ground and river water contamination.

The genus Fusarium is widely distributed in soil and in association with plants. They are harmless saprobes and are relatively abundant members of the soil microbial community (Bolster *et al.,* 2006).

Aspergillus flavus is a common mold in the environment and predominantly a saprophyte which grows on dead plant and animal tissue in the soil. Many species of *Cladosporium* are commonly found on living and dead plant materials (Chiroma *et al.,* 2007).

In the present study microbes detected include mostly soil bacteria and fungi and showed the absence of pathogenic microbes. The study indicates that the quality of ground and river water has not been contaminated by pathogenic microbes by effluent discharge from textile dyeing units.

SUMMARY AND CONCLUSION

5. SUMMARY AND CONCLUSION

An attempt has been made to assess water quality in a textile dyeing industrial area.

- Madathukulam block in Udumalpet of Tiruppur district was chosen for the present study.
- Tiruppur district is the textile hub of india. Udumalpet is an industrial town with number of textile, paper and farming related industries.
- Most of the textile dyeing and bleaching units in Udumalpet are concentrated in the study area. Amaravathy river flowing through the study area receives effluent discharged by textile industries.
- To assess the water quality in the study area, surface, ground and tap water samples were collected along with the textile dyeing effluent.
- The surface water sample was collected from the river, downstream from the point of discharge of the effluent.
- Tap water is the water from Tirumurthy dam on Amaravathy river which is supplied for domestic use.
- Ground water sample was collected from a bore well in Madathukulam where there is a clustering of textile dyeing and bleaching industries.
- The effluent sample was collected at the discharge point from where it flows into the river.
- Water samples were collected in clean sterile plastic bottles of two litres capacity and stored in a refrigerator at 4^0C before they were use for analysis.

- The water samples were analysed for the physicochemical and microbial parameters.
- Physicochemical parameters were analysed using the standard methods (APHA, 1992).
- The physical parameters analysed were colour, odour, electrical conductivity, temperature, total suspended solids, total dissolved solids and total solids.
- The chemical parameters analysed were pH, alkalinity, total hardness, DO, BOD, COD, chlorides, sulphates, phosphates, fluorides, nitrate nitrogen and nickel.
- The microbiological analysis such as detection of coliform bacteria, MPN count, enumeration of bacterial and fungal populations and their identification were carried out.
- Detection of coliform bacteria was done by using the three basic tests – presumptive, confirmed and completed test.
- The number of colony forming units of bacteria and fungi were estimated using plate count technique.
- The bacterial and fungal strains were isolated and identified using plate count method.
- The effluent sample was characterized for their polluted potential.
- The results of the physicochemical analysis show that the textile effluent is characterized by the presence of colour, objectionable odour, high electrical conductivity, high TDS values, high BOD and COD, low DO, high amounts of chlorides and sulphates.
- To assess the impact of wastewater of textile dyeing and bleaching industries on water quality, surface and groundwater samples were

analyzed for their physicochemical properties and microbial contamination.

- Tap water analysis was carried out and a comparison of water quality parameters of tap and river water samples was made to assess the pollution load of the river water.
- From the comparative study it is clear that the following parameters of the river water showed a marked change. EC, TDS values were much higher. P^H was slightly alkaline. Total alkalinity showed slight increase. DO was low. BOD, COD values were high. Chlorides showed a maximum increase.
- Thus the physicochemical properties of river water are getting altered by the effluent flow into the river. The pollution load may still increase as the river passes through Karur town, another major textile city in Tamil Nadu.
- The ground and river water sample gave positive results for bacterial and fungal contamination. They showed negative results for the presence of coliform bacteria.
- The major bacterial colonies isolated and identified were *Micrococcus luteus* and *Bacillus subtilis*.
- Major fungal colonies isolated were *Aspergillus flavus, Fusarium, Rhizopus* and *Cladosporium.*
- In the present study microbes detected include mostly soil bacteria and fungi and showed the absence of pathogenic microbes. The study indicates that the quality of ground and river water has not been contaminated by pathogenic microbes by effluent discharge from textile dyeing units.

- The study on ground water quality assessment showed that the parameters pH and alkalinity are within the maximum desirable limit and the other parameters. TDS, total hardness, chlorides, sulphates, nitrates, fluorides are within the maximum permissible limit, prescribed for ground water for drinking purpose. Therefore, it is concluded that the ground water in the study area is quiet safe for drinking.

Conclusion

- The study addresses the physicochemical characteristics of the textile effluent and warrants remedial measures to safe guard the environment.
- It is recommended that the disposal of industrial waste water without proper treatment should be discouraged and continuous monitoring of water quality is imperative to ensure the protection of water resources from further degradation.

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