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Physico-chemical parameters of dispersed effluent from textile industries at dollar city

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Abstract

The case study reveals the comprehensive physico-chemical parameters of the dispersed effluent from industries of the dollar city (Tirupur) Tamil Nadu by using biological method that represent heavy source of environmental pollution that entered the water reservoir. The physicochemical properties were analyzed, both physical and chemical parameters and treated with biological method. Physico-chemical parameters like pH, Color, Total dissolved solid (TDS), Electrical conductivity (EC), Biochemical oxygen demand (BOD), Chemical oxygen demand (COD), Turbidity, Total Hardness, Chloride, Oil and grease had seen in effluent samples from different places were assessed. The effluent sample were triplicated and analyzed by above parameters separately. The results were correlated with the water quality standards as per EPA (Environmental Pollution Agency), BIS (Bureau of Indian Standard) and WHO (World Health Organization) norms. Sample from Vijayapuram contains high color (9.7±0.5), TDS (3672±2), total hardness (620±3) and BOD (218±3) values, according to the physicochemical analyzed. Sample Sidco has high chloride levels (995±3), total hardness (620±3) and BOD (218±3), while sample Alangadu has high EC (1983±2) and TSS (377±3) levels, while Rayapuram has high pH (8.5±0.1), COD (821±2) and Oil & grease level (67.4±2) as well as increases in BOD, COD, and pH fluctuation, are the causes of the effluents colour discharge observed respectively. The analyzed quantity of all samples exceeded the prescribed Standard limit. The textile effluent was one of the sources for the major pollutant that affect the water reservoir and the flora and fauna existing in the particular environment and affect the life cycle. The present study strongly recommends that the treatment for the textile effluent before the dispersion to the nearer water reservoirs.

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Introduction

Noyyal River is a tributary of the River Cauvery and originates from the Vellingiri Hills of the Western Ghats in the Coimbatore district of Tamil Nadu, South India. The Coimbatore district got maximum rainfall from South-West monsoon followed by the North-East monsoon and is very close to Western Ghats. It is located 410 meters above sea level with moderate climate and average annual rainfall of 61.22 cms. The river has moderate to good flow for a short period during the North–East and South–West monsoons and flows over a distance of 180 km in an area of 3510 km². It passes through seven taluks (Coimbatore, Tirupur, Avinashi, Palladam, Karur, Erode and Dharapuram) in four districts (Coimbatore, Erode, Karur, and Trichy). The boundary of this river is in north latitude of 10.54' – 11.19' and North Eastern longitude of 76.39' – 77.5'.

The river supplies water to several Tanks located in and around Coimbatore. The area of land irrigated by the river in Coimbatore district is approximately 1600 acres (Palanivel and Rajaguru, 1999).

Effluent dispersed from the industries was the one of the main source for the pollution. Industries were generating the contaminated air, water and soil in the form of effluents were associated in causing serious disease burden (WHO, 2002). In developed and developing countries like India, Textile project were considered as the important part of industrial sector. The textile industry with operations and processes are as diverse as its products and said to be the one of the most complex manufacturing industries. Due to this diversity it is almost impossible to describe a "typical" textile effluent (Sofia *et al.*, 2000). Numerous waste products are produced by the process used to turn cotton fabrics, dyed fabrics and synthetic fibers into textiles and colorful garments. However, the primary source of the textile industries environmental issue by effluent was dispersed that occur during the dyeing and finishing operations (Aslam *et al.*, 2004). These effluents are also the carrier of dyes, organic and inorganic materials such as high quantity of Cl, Pb, Fe, Fl and other heavy metals (Muralikrishnan, 2017).

Heavy metals present in textile effluents (either in free form or in suspended solids) are also carcinogenic (Sathiyaraj *et al.*, 2017). A variety of cleaning procedures were used in textile finishing operations in order to eliminate contaminants and give the material the appropriate tactile and visual qualities.

Scouring, bleaching, dying, dye fixing, and fabric softening were the main processes involved in fabric dyeing. Before additional wet processing, scouring was carried out using alkaline baths to eliminate contaminants. Before completed clothing was put on the market, it was necessary to wash it using detergents and softeners to get rid of impurities and enhance the texture of the fabric (Ntuli *et al.*, 2009).

The dyeing process in textile industries involves more than 8,000 chemical products that include sulfides, salts, formaldehydes, metals and surfactants (Bhatia *et al.*, 2017). During this process, approximately 10-25% of dyes used have been lost and about 2-20% of it is discharged with effluents in different environmental components. Thus, large levels of suspended solids, dissolved solids, unreacted dyestuffs (colour), BOD, COD, heavy metals, and other auxiliary chemicals employed in the various stages of dyeing and other processes are found in wastewater produced by the textile processing industries (Khan and Malik, 2014; Mahfuza *et al.*, 2009; Deepali and Gangwar, 2010; Awomeso *et al.*, 2010; Amin *et al.*, 2008; Adebayo *et al.*, 2010). Three primary steps were involved in the processing of cotton and cotton-based textiles: spinning, knitting or weaving, and wet processing.

Finished in textile manufactures were refers to the steps taken to transform the knitted or woven fabric into a material that can be used, particularly any step taken after the yarn or fabric had been dyed to enhance the appearance, functionality, or "hand" (feel) of the final garment or textile (Kadolph and Sara, 2007). While some finishing methods, like bleaching and dyeing, were applied to yarn prior to weaving, others were applied to the grey fabric immediately upon knitting or weaving. The selection of raw cotton to its finishing and pollution. Characterizing textile wastewater is necessary in order to look into the best treatment solutions and assess the treatment plant because, as was previously noted, it contains significant pollution loads in terms of temperature, colour, pH, COD, BOD, TDS, TSS, and EC. The characterization of textile wastewater in Tami Nadu, India generally and Tirupur textile industries specifically, however, has received relatively little attention. The study evaluated the physico-chemical properties of wastewater from the Tirupur textile industry and nearby water bodies including colour, odour, temperature, pH, TSS, TDS, BOD, COD and EC were represented.

Materials and methods

The samples were collected from Noyyal river in 4 different places they were SIDCO, Vijapuram, Alangadu and Rayapuram which is situated near the textile industries. Tirupur is located on the bank of Noyyal River, a tributary of river Cauvery. It lies between 110100 N to 11 0220 N latitude and 770210 E to 77 0500 E longitude. The waste water were collected in a sterile Polyethylene Terephthalate (pet) container. The sterilization were carried by cleaned by non-ionic detergent and tape water and then soaked in 10% of HNO_3 for 24 hours finally rinse it with deionized water. The sampling containers have been washed after the collection. The collected sample were stored at 4˚C and analyzed separately in both physical and chemical parameters like pH, Color, Total dissolved solid (TDS), Electrical conductivity (EC), Turbidity, Calcium Hardness, Total Hardness, Magnesium, Nitrates, Sulphates, Chloride, Dissolved Oxygen, Potassium, Phenol and Phosphates were analyzed through the methods as mentioned in (Table 1) and by correlated with the water quality standards method as per EPA (Environmental Pollution Agency) and BIS (Bureau of Indian Standard) norms mentioned.The observed data were analyzed by Minimum Concentration, Maximum Concentration, Mean Concentration and Standard deviation. The precision of the all analyses were measured using the standard deviation and calculated in mg/L for the each sample respectively.

Results and discussion

Effluent had been evicted directly straight to the Noyyal river through the main drain network linked with it at Tirupur. The enormous amount of un-treated textile azo dye waste were dispersed by the textile printing units (Ardon *et al.*, 1996). The physicochemical properties of dispersed effluent to water reservoirs were analyzed and tabulated (Table 2).

Table 1. Collection of textile effluents of Dollar city Tirupur, Tamil Nadu

Sampling sites	Common name	C.I. generic name	Chemical formula
Sidco	Red dye	Solvent Red 43	$C_{20}H_8Br_4O_5$
Vijayapuram	Brown dye	Acid Brown 14	$C_{26}H_{16}N_4Na_2O_8S_2$
Alangadu	Black dye	Carbon Black	C
Rayapuram	Purple dye	Acid blue 1	$C_{27}H_{31}N_2NaO_6S_2$

Table 2. Physicochemical parameters of different textile effluents

Effluent sample	Color (Hazen)	pH	Electrical conductivity (mS/cm)	TDS mg/L	TSS mg/L	Total harness mg/L	Chloride mg/L	COD mg/L	BOD mg/L	Oil & Grease mg/L
Sidco [S1]	9.4±0.5	8.3±0.1	1254±3	3058±3	328±3	459±2	995±3	434±3	168±2	82±2
Vijayapuram [S2]	9.7±0.5	8.4±0.05	1849±6	3672±2	246±6	620±3	874±1	378±1	218±3	37±3
Alangadu [S3]	9.2±0.5	8.4±0.1	1983±2	3241±2	377±3	527±4	987±4	551±1	126±1.7	50±1
Rayapuram [S4]	5.7±0.5	8.5±0.1	1594±6	2926±3	155±2	541±2	819.3±2	821±2	78.6±0.5	67.4±2
BSI Limit	25	6.5-9	1000 (WHO)	2100	100	500	600	250	100	10

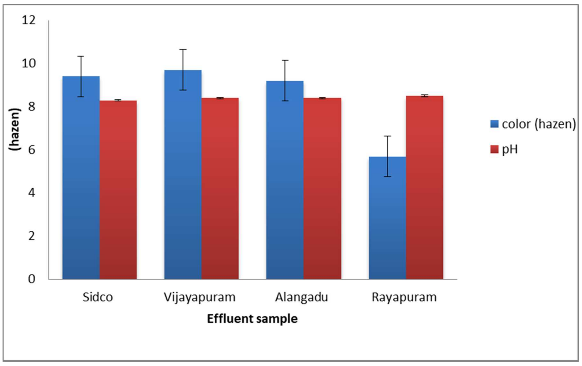

Fig. 1. Analysis of colour in effluent samples

In the textile industry effluent was one of the major and primary pollutants it was formed by fabric dying. It gradually differs from industries typical dye marks used. Selected Effluent color was easily visible showed in (Table 1) and the true color was measured by absorbance using Platinum-Cobalt (Pt-Co) and also as standard in UV-Visible spectrometer at the wave length of 410 nm. The lowest color unit were found in Rayapuram (5.7±0.5) and other samples ranges in (9.2±0.5 to 9.7±0.5) Hazen (BSI limit: unobjectionable / agreeable due to the aesthetic consideration) (Fig. 1). The most demanding problems dye stuffs were water-soluble, intensely colored, acid and reactive dyes by the way acid azo dyes were found in most of the sample collection site. It was extremely difficult to remove the acid dyes and cationic mordant using traditional treatment procedures, despite the fact that they are removed at high removal rates (Anjaneyulu *et al.*, 2005). However, focus had been paid to the removal of the dye using a combination of physical and chemical using biological treatment approaches (Garg and Tripathi, 2017). The study findings show that the effluents contain highly harmful metals and color-producing substances that were obtained during the dyeing and bleaching of clothes, rendering the receiving water unfit for future use (Elango *et al.*, 2017) also noted that color produced by the use of various dyes in the textile production process is one of the main issues with textile effluents. By obstructing sunlight and decreasing reoxygenation, it inhibits photosynthesis and impedes the development of photoautotrophic organisms. Other factors like BOD and dissolved oxygen are also impacted. By stopping chromophores from degrading temperature and the effluent's pH also determined. All the sample smells pungent which be caused due to the human contaminants. Heavy metal presence which also affects the pH was an important factor to be determined in the analysis of water quality, since it affects chemical reactions such as solubility and metal toxic and alters biological reaction rates, thus causing adverse effects on the survival of aquatic plants, animals and humans. pH was the main primary and preliminary assessment in deciding the quality of effluent. The pH of about 10 were exceptional and the water may be with the contaminants of strong bases like NaOH and $Ca(OH)_2$ (Langmuir, 1997). The collected samples of pH values indicate a somewhat alkaline character, with S1 having the lowest pH at 8.3±0.1 and Rayapuram having the highest at 8.5±0.1 (BIS limit: 6.5 to 9) (Fig. 1). The use of various dyes during the process could be the cause of the alkalinity. Likewise, Vigneshpriya and Shanthi (2015) demonstrated that an effluent sample taken from Tamilnadu textile hub of Karur had a pH of 9.5. Patel *et al.* (2015) discovered that the pH range of the textile industry wastewater that was gathered from Gujarat's southern districts was 4 to 13. In addition to regulating chemical treatment procedures, pH affects plant growth, aquatic animal survival, and the activity of beneficial microbes. Which revels the effluent collected from the Noyyal river was alkaline due to the textile dying and printing process in Tirupur. The buffering capacity of the water system in the effects to the alkalinity which have to be monitored frequently. Due to the alkalinity of the effluent waste water and It's capacity to be neutralized by acid, but it must be disaster. Thus the physical and chemical properties of the effluent dispersed in Tirupur Noyyal river which adversely affect the flora, fauna and humans too. Its results lead by polluting the underground water resource through the change in soli permeability (Gupta and Jain, 1992). By the review of the other textile industries expelled effluent shows the parallel result pH as described and alkaline nature (Gowrisankar *et al.*, 1997). The soil structure, permeability and irrigation were affected due to the high EC in the water. The Conductivity is measured to establish the pollution zone around an effluent discharge (Anjaneyulu *et al.*, 2005). EC of the analyzed effluent was found sample area Sidco, Vijayapuram, Alangadu and Rayapuram 1254±3, 1849±6, 1983±2 & 1594±6 (mS/cm) respectively (Fig. 2). Usually the natural water reservoirs EC value was 20- 1500 (mS/cm). However, the standard limit set by WHO is 1000 (mS/cm). The total amount of organic and inorganic materials presents in water in molecular, ionized, or suspended form is measured by TDS. There were soluble salts that produce ions, such as carbonate, bicarbonate, calcium, chloride, magnesium, nitrate, phosphate, sodium, and sulfate. In addition to giving water a laxative effect and an unpleasant mineral flavor, dissolved salts in water dehydrate animals skin. It lowers the development and yield of most plants by raising the osmotic pressure of soil water, which raises respiration rate. It can occasionally raise the temperature as well (Leelavathi *et al.*, 2016). TDS levels in the effluent ranged from 2926±3 mg/L in S4 to 3672±2 mg/L in S2. When compared to samples from Rayapuram, TDS values were found to be greater in the Vijayapuram area especially in the Alangadu sample. The values found are significantly higher than the 2,100 mg/L tolerance limits recommended by the Bureau of Indian Standards as illustrated in (Fig. 2). The release of chemical agents employed in several textile industry operations could be the cause of this elevated level. Comparing the results, Sathiyaraj *et al.* (2017) collected effluents from textile dyeing units in Erode, Pallipalayam and Bhavani, Tamil Nadu, and discovered that the TDS was above the pollution control board (PCB) standard, ranging from 2,459-3,894 mg/L to 6,801-9,870 mg/L. Aquatic life and agricultural perspectives are negatively impacted by this high TDS value which also causes salt issues in the local environment (Kolhe and Pawar, 2011; Roy *et al.*, 2010; Manikandan *et al.*, 2015). The organic and mineral particles found in effluents were represented by total suspended solids. In addition, it contains organic matter, salt, bicarbonates, carbonates, chlorides, phosphates, nitrates, calcium, magnesium, sodium and potassium were analysed. Sample from the Alangadu area had a high TSS value, ranging from 155±2 to 377±3 mg/L. Bureau of Indian. Standards permitted level below the 100 mg/L, whereas samples are beyond the limit (Fig. 2).

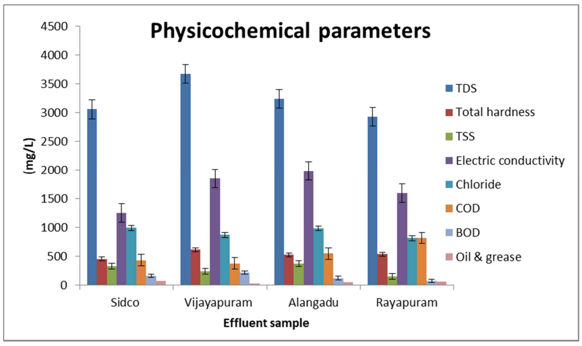

Fig. 2. Physicochemical parameters of textile effluent collected from different places of Dollar city Tamil Nadu

Additionally, Sathiyaraj *et al.* (2017) discovered that the TSS values of the wastewater from textile dyeing facilities and common effluent treatment plants (CETPS) in Tamil Nadu's Erode, Pallipalayam and Bhavani were high, ranging from 222 to 896 mg/L. A high TSS value raises the water's turbidity and sedimentation rates, which affects oxygen consumption and inhibits photosynthesis.

Additionally, it raises pathogen and pollutant levels, which upsets the aquatic biota's food chain (Manikandan *et al.*, 2015). It must therefore be decreased before being dumped into the effluents. The hardness of water, which was represented by $CaCO_3$, was a measured by its quality primarily in terms of Ca^{2+} and Mg^{2+} (Fig. 2) shows that the hardness of the effluent samples ranged from 459±2 mg/L in S1 to 620±3 mg/L in Vijayapuram. The highest allowable limit of hardness, as stated by BIS, is 500 mg/L, whereas the Vijayapuram area has greater levels of hardness (especially in the Sidco and Vijayapuram samples). The fact that sample S1 was lower whereas the other samples were above it suggests that the water was hard. Therefore, before the effluents were released into the receiving bodies, they should be softened. High levels of hardness were noted by (Ramesh *et al.*, 2012) in the effluents gathered from Tirupur's textile mills. The presence of carbonate and non-carbonate chemicals may be the cause of the increase in total hardness (Varma and Sharma, 2011). The surrounding environs become more alkaline and have a higher pH as a result. Fig. 2 illustrates the comparison of the chloride levels in S8 and S3, which were found to be 995±3 mg/L and 987±4 mg/L, respectively, exceeding the BIS tolerance limit of 600 mg/L. It was discovered to be greater in the Sidco and Alangadu region, namely in the S1 and S3 samples. Because bleaching, washing, and disinfection procedures use chemicals like hypochloric acid, hydrochloric acid, and chlorine gas, chloride was only a contaminant at greater concentrations that are released in effluents.

Agricultural crops were impacted by this important anion in industrial effluents (Chaurasia and Tiwari, 2011). It promotes corrosiveness, kills aquatic microorganisms, disrupts the aquatic food chain, and may have negative health impacts on people. It also affects sulphate levels, TSS, TDS, alkalinity, and electrical conductivity. Because of the increase in mineral content, water with a chloride concentration above 250 mg/L tastes salty. Chloride concentrations in effluents gathered from Tirupur's textile factories ranged from 145 to 1,668 mg/L, according to (Ramesh *et al.*, 2012). COD was a metric used to quantify the oxygen demand of oxidisable contaminants in effluents. According to (Yusuff and Sonibare, 2004), it shows the degree of toxicity and the existence of biologically resistant materials in water. Fig. 2 shows that the COD of the chosen samples ranges from 378±1, 821±2 mg/L (the normal BIS limit of COD was 250 mg/L). The Rayapuram region had a higher COD value, especially in the S4 sample. According to (Giller *et al.*, 1998), the COD levels were extremely high, ranging from 800-2,304 mg/L, and they were higher than what was allowed to be mixed on inland water surfaces. The inclusion of non-biodegradable dyeing chemicals, softeners, and detergents wasted throughout the process may be the caused due to the high COD value, which indicates the toxicity of the effluents (Thangaraj *et al.*, 2017). In order to ensure the survival of aquatic life, the wastewater was treated. The amount of oxygen needed by bacteria in water to break down decomposable organic matter into simpler chemicals was measured by the BOD. High BOD levels indicated that there was less oxygen available for the wastewater's living organisms and are a sign of the water's level of pollution. The water was significantly contaminated as evidenced by the samples' BOD levels which ranged from 78.6±0.5mg/L in Rayapuram to 218±3 mg/L in Vijayapuram, compared to the normal BIS limit of 100 mg/L (Fig. 2). The Vijayapuram area has a higher BOD value, especially in the Vijayapuram sample. The fact that sample Rayapuram was lower than BSI whereas the other samples were above it suggests that the water demand in oxygen (Fig. 2). High BOD levels were found in the wastewater of textile dyeing facilities in the Pallipalayam neighbourhood of Namakkal District, according to Tishmack and Jones (2003). By reducing dissolved oxygen, the elevated BOD level raises the water's anaerobic qualities and may deplete the aquatic biota through hypoxia and other negative impacts (Kaur *et al.*, 2010; Sathya *et al.*, 2022). A film layer forms on the water's surface when oil and grease, which are organic hazardous waste, are dumped in effluents. It damages the aquatic ecosystem by lowering the dissolved oxygen, which in turn lowers biological activity. Fig. 2 shows that the concentration of oil and grease in the chosen effluents is 37±3 - 82±2mg/L, which was much higher than the BIS limit of 10 mg/L. In comparison to other samples, the value was found to be higher in the Sidco area. Elango *et al.*, 2017 and Abdouni *et al.*, 2021 also found that the oil and grease concentration in the textile dyeing wastewater collected in Tamilnadu's Tirupur regions was 18 mg/L. The suspended solid in the effluents combine with oil and grease in water bodies and obstruct the photosynthesis process, reducing the amount of dissolved oxygen (DO) and hence disturbing the growth of aquatic plants and the aquatic food chain. Hence, oil and grease concentration have to be reduced by proper treatment to prevent their accumulation in the water bodies.

The sample from Vijayapuram contains high color, TDS, total hardness and BOD values, according to the physicochemical analysis (Table 2). Sample Sisco has high chloride levels, total hardness and BOD, while sample Alangadu has high EC and TSS levels, while Rayapuram has high pH, COD and Oil and grease level as well as increases in BOD, COD, and pH fluctuation, are the causes of the effluents' colour discharge (Amin *et al.*, 2008; Ameh *et al.*, 2023). The effluents COD concentrations were three to 10 times greater than their corresponding BOD values, indicating that enhanced intrinsic remediation necessitates a substantial amount of dissolved oxygen. The high parameter values from every sample under study demonstrate that Tirupur City effluents were disposed with a high pollution load. The Noyyal river basins, as well as nearby surface and groundwater, were contaminated by these effluents from the textile, dyeing, and chemical industries.

Physiochemical analyses of several industrial effluents (Kaur *et al.*, 2010; BIS, 2012; Srivastava, 1988) are consistent with the results obtained.

When these effluents combined with groundwater, the concentration of pollutants rose, rendering the water unsafe for human consumption. The Tirupur district's groundwater analysis revealed that Vijayapuram contains high color, TDS, total hardness and BOD were estimated, than the Rayapuram regions, while the Rayapuram regions had higher levels pH, COD and Oil and grease, sulphate, and iron. The waste water treated before consumption because all the physicochemical characteristics are beyond the permissible limits (Dinesh and Geetha Selvarani, 2016). Due to the release of untreated industrial effluents, it was also discovered that the soil's salt and alkalinity had grown, causing soil issues. Fields with high BOD and COD levels experience clogged soil pores, which reduces soil productivity (Dinesh and Geetha Selvarani, 2016; El Hafidi *et al.*, 2024; Ratnaparkhi, 2024). Certain heavy metals present in discharge effluents accumulate in biological sources and ultimately cause serious health issues for people including dermatitis, skin irritation, nausea, hemorrhage, and ulcers (Tufekci *et al.*, 2007; Sathya and Ravichandran, 2007). These effluents have been treated using a variety of wastewater treatment techniques. However, the treatments were costly and necessitate intricate operations and maintenance and they have not shown to be efficient in eliminating all dyes, chemicals, heavy metals and other inorganic pollutants utilized in the business (Rajasulochana and Preethy, 2016; Jingxi *et al.*, 2020; SamehSamir *et al.*, 2025). These contaminants and preserve the resources, appropriate new methods with a low cost range must be created. In order to eliminate the pollutant loads targeted specifically for micro companies, a prototype model of an effluent treatment plant using inexpensive materials is being developed.

Conclusion

The physicochemical properties of the textile effluents from various locations in Tirupur, including color, pH, total hardness, BOD, COD, TDS, TSS, total chloride, oil, and grease, were assessed using Indian Standard techniques for water sampling and testing. These results were then compared with wastewater generation standards as established by the Bureau of Indian Standards. According to the research, the parameters are too high to be thrown out into the environment. The Vijayapuram and Alangadu region's sample particularly had high pollution levels, while other samples had noticeably greater levels. When these effluents are disposed of improperly, they contaminate groundwater and surface water, rendering it unfit for irrigation and drinking. Both the aquatic and terrestrial ecosystems are impacted. Small-scale industries cannot afford the process economically due to the high cost of conventional treatment methods, even though initiatives for waste minimization and cleaner production technologies were promoted in many industries and common effluent plants were established in many textile industry areas. In order to prevent the threat of major livelihoods that depend on wastewater on the one hand, and the deprivation of rich natural resources on the other, cost-effective, advanced and user-friendly solutions for treating wastewater from medium and small-scale businesses was now been developed.

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