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Investigation on the efficiency of common effluent treatment plant on the reduction of textile effluent physicochemical parameters and toxicity

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Abstract

Textile industry effluent treated through different stages in Common Effluent Treatment Plant (CETP), Perundurai Region, Tamil Nadu, India, was analyzed for efficiency in reduction of effluent physicochemical parameters. The toxicity reduced in the treated effluent was tested using freshwater fish Labeo rohita through histopathological analysis. The untreated effluent showed lower fish 96hLC_{50} values of 10% indicating higher toxicity. The biological treatment of textile effluent (involving bacteria) followed in the CETP (Stage I) resulted in 90% decolourization of the effluent. Whereas, the biologically treated effluent resulted in lower fish 96hLC_{50} values of 50%. The chemical treatment process followed by biological treatment in the CETP increased the decolourization to 95%, along with subsequent increase in fish 96hLC_{50} values of 75%. Further treatment of the effluent through hydraulic press, chlorination, dual media filter press had resulted in total decolourization of the effluent to 97%, along with higher reduction in effluent physicochemical parameters and metal ions. Toxicity analysis revealed that the fish could only survive acute toxicity test due to partial reduction of toxicity in the treated effluent, hence unsuitable for its the release into natural water bodies. However the treated effluent with reduced effluent parameters after reverse osmosis can be reused further in textile processing. The total recovery of water after treatment was 85% respectively and the production of secondary sludge 1.4gL^{-1}.

Keywords: Textile dye effluent, Bioremediation, Common Effluent Treatment Plant, Fish toxicity, Histopathological indices.

Introduction

Raw textile effluent (RE) from dyeing industries possesses high colour intensity due to complex mixture of aromatic and heterotrophic dyes with low degradability[1]. In addition it possesses high pH, physicochemical parameters and other toxic additives[2]. Due to the release of about 96.1 million litres of effluent per day into the Noyyal river (tributary of Cauvery), Tamil Nadu, India; the levels of TDS, metal ions and unwanted salts are higher than the permissible levels in the river[3]. The higher colour and BOD in the discharged effluent can lead to rapid depletion of oxygen, affect photosynthesis and make the aquatic body unfit for survival of aquatic animals[4]. The Common effluent treatment plant (CETP) is operated by the State Industries Promotion Corporation of Tamil Nadu in Perundurai, Erode District, Tamil Nadu, India, in order to treat the textile dye effluent produced in bleaching and dyeing industries in and around Perundurai region, Tamil Nadu, and prevent the release of the effluent into the surrounding water bodies[5]. The main aim of CETP is to significantly reduce the pollution load in the textile effluent, whose release into natural environment will pollute land, surface and ground water, affecting fisheries and agriculture[6]. CETP has six main treatment stages to treat the RE involving Aeration Tank, Flash Mixer Tank, Hydraulic Press, Chlorination, Dual Media Filter and finally through the two stages of reverse osmosis[7]. Bacteria *Escherichia coli* is employed for the degradation of dyes present in the effluent at stage I of the treatment process (aeration tank)[8], and further use of lime and ferrous sulphate in the chemical treatment process further coagulate the effluent constituents[9], later the effluent is chlorinated and filtered. In this study the efficiency of the CETP treatment process at different stages in the reduction of effluent toxicity is evaluated through physicochemical parameters and fish toxicity studies[10]. Fresh water fish *Labeo rohita* is used as an aquatic model in the present study.

Materials and methods

Treatment stages of CETP: Necessary volume of RE and the treated effluent from all stages were collected from CETP, Perundurai, Tamil Nadu, India. The preliminary RE treatment in CETP includes adjustment of effluent temperature and flow rate at the equalization tank for a time duration of 24 hours (in Primary Clarifier). The effluent is further subjected to a five stage treatment as given below. **Stage I** - Aeration Tank where the RE is biologically treated using aerobic bacteria *Escherichia coli.* The sludge produced in this stage is removed in Secondary Clarifier Tank. **Stage II** – The effluent is then chemically treated in a Flash Mixer Tank by addition of lime (1.2g/L) to

increase the pH of the effluent so as to form metal hydroxides. In this stage ferrous sulphate (0.2g/L) and polyelectrolytes (0.5g/L) were also added to increase the rate of flocculation and settling of sludge. The effluent then passes through a Tertiary Clarifier Tank where the pH of the effluent is made acidic by adding sulphuric acid. **Stage III -** This stage, named as Hydraulic Press, is focused to separate the solid sludge from the liquid using a compressor. **Stage IV -** The effluent is further chlorinated using sodium hypochloride for disinfection of the effluent. **Stage V -** The effluent now passes through Dual Media Filter filled with pebbles, gravels and sands for further purification of the effluent, and finally the treated effluent goes through **Stage VI** - two stage of Reverse Osmosis processes[7], later the water is either recycled for industrial use or released to water bodies.

Decolourization level: UV-Visible Spectrophotometric analysis (Shimadzu UV-1800) was performed at regular intervals of 24 hours to measure the decolourization percentage of the treated effluent, following the method adopted by ADMI (American Dye Manufacturers Institute), and recorded in ADMI values[11]. The colour removal was recorded in

ADMI removal % = (Initial ADMI - Final ADMI/ Initial ADMI) x 100

Analysis of effluent parameters: The pH of the samples was analyzed using standard pH meter. The physicochemical parameters which include turbidity, Total Solids (TS), Total Dissolved Solids (TDS), Total Suspended solids (TSS), Electrical Conductivity (EC) were determined following the protocol of Standard Method for the Examination of Water and Wastewater[12]. The Biological Oxygen Demand (BOD) was calculated following titrimetric method, while the Chemical Oxygen Demand (COD) is calculated by Open Reflux method. Sodium and potassium ions were determined by Flame Photometer. Phosphate, nitrate, nitrate, silicate, chloride (Mohr's), ammonia (sulphuric acid titration), bicarbonate and carbonate were determined by titration method, sulphate by Gravimetric method, concentrations of heavy metals (calcium, magnesium, iron, fluoride, manganese, copper, zinc, lead, cadmium, chromium, cobalt, mercury) using Atomic Absorption Spectroscopy (SIMADZU, Model-AA3800/G)[13]. Oil, grease and phenolic compounds were determined by chromatography procedure following the method of Rauckyte *et al*[14]. Significance of difference between the RE (control) and the treated groups of RE (results of experiments pursued in triplicates) were analyzed using One way ANOVA followed by **Tukey's post hoc test**, with $p \leq$ level at 0.05 to check the interactive effects between different parameters.

Fish toxicity analysis: The fish toxicity experiments were carried out following Institutional Animal Care and Use Committee (IACUC) guidelines, 2004. For aquatic toxicity analysis fish *Labeo rohita* were purchased from a fish farm at Thanjavur, Tamil Nadu, India. Fish of length 12 ± 0.5 cm, width 2 ± 0.2 cm and weight 18g ± 1g were chosen for experimental studies, and acclimatized in the laboratory for a period of 2 weeks[15]**.** They were maintained in alternating light and darkness for a period of 12:12 hours, in 100 litre tanks at pH 7.4, temperature 25 ± 2°C and dissolved oxygen 6.54 ± 1.2 mg/L[16]. Different concentrations of the RE and the treated effluent were prepared for toxicity analysis (without alteration of effluent pH) in order to determine fish 96hLC_{50} values. The dissolved oxygen of all the effluent samples was adjusted to 6.54mg/L ± 1.2mg/L. Exactly 20 fish were added to 20 litre of effluent samples prepared for experimental analysis.

Fish histopathological analysis and evaluation: Fish exposed to RE and treated effluents at different stages were dissected to collect individual gills, liver and kidney for histopathological analysis. These tissues were preserved in Davidson's solution for 24h at 4ºC and later stored in 70% ethanol. The samples for histopathology were processed following the protocol adapted by Hassaninezhad *et al*[17]. The slides prepared were examined under an optical microscope (Zeiss X 100) for histopathological damage. Histopathological damages were identified. The histopathological indices (*I*) involving the total lesions of an individual organ (I_{org}), exposed to different treatment category were calculated following the protocol proposed by Bernet *et al.*[18] using the formula

$$I_{org} = \sum_{rp} \sum_{alt} (a_{org\ rp\ alt} \times w_{org\ rp\ alt})$$

Where org = organ (constant), rp = reaction constant, alt = alteration

Histopathological condition indices were calculated for every damage in organs (gills, liver and kidney) of all the treatment categories. The importance of various factors on each type of damage (w = 1 to 3) and the scores (a = 1 to 6) for each organ was given based on the extent of damage's in its structure[19]. The damage concerning necrosis of gill interlamellar space, liver hepatocyes and kidney mesenchymal cells are given an importance factor of 3. The damage concerning aneurysm of secondary gill lamella, atrophy of gill interlamellar space, apoptosis of lievr hepatocytes, infilteration of leucocytes in the liver and degeneration of kidney glomerulus are given an importance factor of 2. The damages concerning clubbing of secondary gill lamella, curling of secondary gill lamella, fusion of secondary gill lamella, detachment of primary lamellar gill epithelium, vacuolation of liver hepatocytes, detachment of liver hepatocytes, occulation of kidney tubular lumen and detachment of kidney mesenchymal cells were given an importance factor of 1.

Results and discussion

Reduction of effluent physicochemical parameters: The RE showed extremely higher levels of turbidity, BOD, COD, and marginally higher levels of total dissolved solids and electrical

conductivity when compared with the General Standards for discharge of Environmental Pollutants for Effluents[20]. Similarly the concentrations of metal ions especially chloride, fluoride, sodium, calcium, magnesium and ammonia were very high. The decolourization of the effluent after treatment processes in CETP Stage I was 90%. This was further increased in chemical treatment processes to 94%, and finally after the treatment processes in CETP Stage V the effluent decolourization rate is increased to 97% (Table-1).

The final treated effluent of CETP showed neutral pH. The reason for increased rate of effluent decolourization is attributed to 91% decline in turbidity, 61% in total solids, 58% in total dissolved solids, 95% in TSS, 58% in electrical conductivity, 85% in BOD and COD (Table-2). The reduction in metal ions were 52% of chloride, 49% of bicarbonate, 54% of sulphate, 86% of silicate, 42% reduction in fluoride, 94% of nitrate, 87% ammonium, 75% of phosphate (Table-3), 79% sodium, 60% of calcium, 33% of magnesium, 50% of potassium (Table-4), 82% of zinc, 92% of iron, 66% of manganese , 95% of chromium, 83% of lead, 81% of copper, 75% of cadmium and 100% reduction in cobalt and mercury (Table-5). The reduction of oil and grease was 83%, and phenolic compounds of 66% (Table-6).

Table-1: Percentage and time of decolorization of RE using the treatment methodology of CETP.

Treatment Parameters	Decolourization (In %)
CETP Stage I(a) - Aeration tank	80.58
CETP Stage I(b) - Secondary clarifier	90.58
CETP Stage II (a) - Flask Mixer tank	92.31
CETP Stage II (b) - Tertiary clarifier	94.00
CETP Stage II (c) - Addition of H_2SO_4	94.11
CETP Stage III - Hydraulic press	96.41
CETP Stage IV - Chlorination	97.64
CETP Stage V - Dual media filter	97.65

Table-2: Variation of physical parameters in the treated effluent following the methodology adopted by CETP.

	pH	Turbidity	TS	TDS	TSS	EC	BOD	COD
Raw Effluent	8.30 ± 0.16	1400±25.27	2470±34.21	2280±51.61	189±07.54	3.56±0.12	983±11.57	1589± 50.52
CETP Stage I (a)	7.82 ± 0.03[a]	1320±28.02	1754±28.82[a]	1626±19.47[a]	128±10.07[a]	3.03±0.15	585±11.78[a]	853 ± 13.59[a]
CETP Stage I (b)	7.76 ± 0.07[a]	150±3.53[a]	1351±22.24[a]	1306±5.24[a]	45±25.48[a]	2.54±0.34[a]	289±19.40[a]	542 ± 20.17[a]
CETP Stage II (a)	7.69 ± 0.06[a]	145±1.45[a]	1182±39.53[a]	1146±8.02[a]	36±19.06[a]	2.04±0.34[a]	189±09.52[a]	374 ± 12.41[a]
CETP Stage II(b)	7.62 ± 0.07[a]	150±2.91[a]	1066±38.85[a]	1043±9.60[a]	36±15.23[a]	1.79±0.26[a]	176±12.44[a]	296 ± 14.43[a]
CETP Stage II (c)	7.50 ± 0.13[a]	75±2.88[a]	1242±05.03[a]	1210±3.84[a]	32±16.01[a]	1.89±0.17[a]	168±10.17[a]	287 ± 15.92[a]
CETP Stage III	7.29 ± 0.20[a]	125±6.01[a]	1023±22.19[a]	1005±3.18[a]	18±13.23[a]	1.57±0.14[a]	152±15.77[a]	269 ± 16.77[a]
CETP Stage IV	7.45 ± 0.11[a]	100±2.88[a]	1064±16.18[a]	1043±3.48[a]	21±05.49[a]	1.63±0.14[a]	152±05.81[a]	272 ± 10.04[a]
CETP Stage V	7.41 ± 0.06[a]	125±2.88[a]	964±18.36[a]	954±2.03[a]	10±12.49[a]	1.49±0.06[a]	140±06.11[a]	226 ± 07.96[a]
Discharge limit	5.5 - 9	10	3000	2100	200	2.25	100	250

Values are expressed in mean + SE. Turbidity units expressed in NTU, Electrical conductivity is measured in dsm^{-1}, and units of other parameters except pH are expressed in mg/L. The letter a represents significant difference among treatment groups when compared against untreated effluent at $p < 0.05$.

Table-3: Variation of metal anions in the treated effluent following the methodology adopted by CETP.

	Chloride	Bicarbonate	Sulphate	Silicate	Fluoride	Nitrate	Phosphate	Ammonium
Raw Effluent	459±5.23	289±27.00	128±07.57	29.62±1.88	8.91±0.44	16± 0.15	12 ± 0.12	62 ± 0.33
CETP Stage I (a)	398±7.06[a]	288±13.59	108±11.78[a]	4.25±0.06[a]	4.59±0.55[a]	12 ± 0.10[a]	11 ± 0.14	15 ± 0.26[a]
CETP Stage I (b)	365±5.24[a]	287±20.17	98±19.50[a]	3.58±0.14[a]	4.23±0.16[a]	3 ± 0.11[a]	8 ± 0.23[a]	13 ± 0.18[a]
CETP Stage II (a)	380±2.91[a]	268±12.41	124±20.54	4.90±0.12	5.98±0.09[a]	5 ± 0.09	8 ± 0.14 [a]	16 ± 0.22[a]
CETP Stage II (b)	360±2.91[a]	212±14.43[a]	100±12.44[a]	4.70±0.08	5.77±0.07[a]	2 ± 0.05[a]	6 ± 0.05[a]	13 ± 0.36[a]
CETP Stage II (c)	356±3.84[a]	219±15.92[a]	96±10.17[a]	4.69±0.11[a]	5.69±0.09[a]	1 ± 0.03[a]	5 ± 0.04[a]	12 ± 0.24[a]
CETP Stage III	312±3.18[a]	182±16.77[a]	78±15.77[a]	5.32±0.11[a]	5.42±0.08[a]	1 ± 0.02[a]	4 ± 0.03[a]	8 ± 0.25[a]
CETP Stage IV	289±2.03[a]	168±07.96[a]	62±05.81[a]	4.16±0.11[a]	5.36±0.07[a]	1 ± 0.03[a]	3 ± 0.04[a]	16 ± 0.12[a]
CETP Stage V	218±3.48 [a]	148±10.04[a]	59±06.11[a]	4.13±0.10[a]	5.19±0.09[a]	0[a]	3 ± 0.04[a]	8 ± 0.15[a]
Discharge limit	250	-	200	-	1.5	20	-	1.2

Values are expressed in mg/L, with mean ± SE. The letter a represents significant difference among treatment groups when compared against untreated effluent at $p < 0.05$.

Table-4: Variation of metal cations in the treated effluent following the methodology adopted by CETP.

Raw Effluent	Sodium	Calcium	Magnesium	Potassium
CETP Stage I (a)	896 ± 13.42	289 ± 05.49	178 ± 4.16	0.38 ± 0.02
CETP Stage I (b)	652 ± 12.91[a]	258 ± 09.84[a]	168 ± 7.09	0.22 ± 0.01[a]
CETP Stage II (a)	380 ± 04.18[a]	236 ± 05.57[a]	158 ± 5.06[a]	0.19 ± 0.0[a]
CETP Stage II (b)	312 ± 07.35[a]	180 ± 07.79[a]	169 ± 4.35	0.28 ± 0.01
CETP Stage II (c)	250 ± 05.86[a]	121 ± 05.23[a]	152 ± 4.41	0.26 ± 0.01
CETP Stage III	242 ± 04.23[a]	125 ± 02.73[a]	148 ± 4.15[a]	0.26 ± 0.01
CETP Stage IV	230 ± 02.51[a]	132 ± 06.33[a]	123 ± 5.03[a]	0.21 ± 0.02[a]
CETP Stage V	219 ± 02.54[a]	120 ± 04.48[a]	125 ± 6.81[a]	0.20 ± 0.01[a]
Discharge limit	189 ± 06.5[a]	116 ± 05.04[a]	120 ± 4.48[a]	0.19 ± 0[a]
	200	80	150	12

Values are expressed in mg/L, with mean ± SE. The letter a represents significant difference among treatment groups when compared against untreated effluent at $p < 0.05$.

Table-5: Variation in heavy metal contents in the treated effluent following the methodology adopted by CETP.

	Zinc	Iron	Manganese	Chromium	Lead	Copper	Cadmium	Cobalt	Mercury
Raw Effluent	0.28±0.02	0.25±0.01	0.24±0.01	0.19 ± 0.01	0.17 ± 0.01	0.16±0.01	0.08 ± 0	0.03 ± 0	0.002±0
CETP Stage I (a)	0.11±0.01	0.10±0.01[a]	0.24±0.01	0.10 ± 0.01	0.14 ± 0.01[a]	0.15±0.01	0.08 ± 0[a]	0.03 ± 0	0.002±0
CETP Stage I (b)	0.09±0.02[a]	0.06±0.01[a]	0.22±0.01	0.03 ± 0[a]	0.08 ± 0.01[a]	0.15±0.01	0.08 ± 0[a]	0.03 ± 0	0.002±0
CETP Stage II (a)	0.06±0.01	0.06±0.01[a]	0.20±0.01[a]	0.03 ± 0[a]	0.07 ± 0.01[a]	0.10±0.01[a]	0.08 ± 0[a]	0.02 ± 0[a]	0.001±0[a]
CETP Stage II(b)	0.06±0.01	0.06±0.01[a]	0.18±0.01[a]	0.02 ± 0[a]	0.07 ± 0.01[a]	0.08±0.01[a]	0.08 ± 0[a]	0.02 ± 0[a]	0.001±0[a]
CETP Stage II (c)	0.05±0.01[a]	0.06±0.01[a]	0.18±0.01[a]	0.02 ± 0[a]	0.07 ± 0.01[a]	0.08±0.01[a]	0.08 ± 0[a]	0.02 ± 0[a]	0[a]
CETP Stage III	0.05±0.01[a]	0.06±0.01[a]	0.16±0.02[a]	0.01 ± 0[a]	0.08 ± 0.01[a]	0.04±0.01[a]	0.05 ± 0[a]	0.02 ± 0[a]	0[a]
CETP Stage IV	0.06±0.01[a]	0.03±0[a]	0.11±0.02[a]	0.01 ± 0[a]	0.06 ± 0[a]	0.03±0[a]	0.03 ± 0[a]	0[a]	0[a]
CETP Stage V	0.05±0.01[a]	0.02±0[a]	0.08±0[a]	0.01 ± 0[a]	0.03 ± 0[a]	0.03±0[a]	0.02 ± 0[a]	0[a]	0[a]
Discharge limit	15.0	2.0	0.5	2.0	1.0	3.0	0.01	0.05	0.1

Values are expressed in mg/L, with mean ± SE. The letter a represents significant difference among treatment groups when compared against untreated effluent at $p < 0.05$.

Table-6: Variation in oil, grease, and phenolic components in the treated effluent following the methodology adopted by CETP.

	Oil and Grease	Phenolic Compounds
Raw Effluent	0.29 ± 0.01	0.59 ± 0.01
CETP Stage I (a)	0.10 ± 0.02[a]	0.46 ± 0.04[a]
CETP Stage I (b)	0.08 ± 0.01[a]	0.43 ± 0.05[a]
CETP Stage II (a)	0.10 ± 0.01[a]	0.40 ± 0.03[a]
CETP Stage II (b)	0.08 ± 0.01[a]	0.38 ± 0.01[a]
CETP Stage II (c)	0.08 ± 0.01[a]	0.36 ± 0.01[a]
CETP Stage III	0.08 ± 0[a]	0.28 ± 0.02[a]
CETP Stage IV	0.06 ± 0[a]	0.22 ± 0.02[a]
CETP Stage V	0.05 ± 0[a]	0.20 ± 0.02[a]
Discharge limit	10	5

Values are expressed in mg/L, with mean ± SE. The letter a represents significant difference among treatment groups when compared against untreated effluent at $p < 0.05$.

Acute toxicity results and histopathological damage of fish organs exposed to different treatment stages adopted by CETP: The fish exposed to the RE showed 96hLC_{50} values of 10%. The exposed fish showed histopathological damage of aneurysm of secondary gill lamella and atrophy of interlamellar space in fish gills; necrosis of liver hepatocytes; along with necrosis and detachment of kidney mesenchymal cells. Fish exposed to effluent passed through stage I of CETP showed 96hLC_{50} values of 50%, along with histopathological damage of lifting of gill secondary lamella along with detachment of primary lamellar gill epithelium; vacuolation and necrosis of liver hepatocytes; and degeneration of kidney glomerulus. Fish exposed to the effluent that passed through stage II of CETP showed 96hLC_{50} values of 75% along with histopathological damage of lifting of secondary gill lamella and atrophy of gill interlamellar space; necrosis of liver hepatocytes; and degeneration of kidney glomerulus with occulation of tubular luman. Fish exposed to the effluent that passed through stage-III of CETP showed 96hLC_{50} values of 50% along with histopathological damage of curling, clubbing of secondary gill lamella, along with necrosis of gill interlamellar space; apoptosis and necrosis of liver hepatocytes; necrosis of kidney mecenchymal cells. Fish exposed to effluent that passed through the stage IV of CETP survived acute toxicity by surviving for 102 hours along with histopathological damage of clubbing of gill secondary lamella and necrosis of gill interlamellar space, necrosis of liver hepatocytes; and necrosis of kidney mesenchymal cells with occulation of tubular luman. Fish exposed to the effluent that passed through the stage V of CETP survived 110 hours showing histopathological damage of fusion and curling of secondary gill lamella; apoptosis of liver hepatocytes; along with degeneration of kidney glomerulus, occulation of tubular luman, and necrosis of mesenchymal cells. The higher histopathological indices observed in the fish population with necrosis of and apoptosis of fish gill, liver and kidney. So higher histopathological indices were observed in fish population exposed CETP Stage III, IV and V, following CETP Stage II and I (Figure-1).

The very lower 96hLC_{50} value (10%) in RE is due to the toxicity of textile dyes, along with other phenolic compounds in the effluent[21]. The biological treatment involving aerobic bacteria *Escherichia coli* help in the mineralization of dyes and other constituents in the RE[22] which resulted the exposure of the fish to higher concentration of this treated effluent of 50% when compared to RE (which was only 10%). In spite of that, the bacterial intermediates present in the treated effluent of CETP Stage - I seem to have toxic metabolites responsible for higher histopathological indices in the treated fishes. The solid constituents in the effluent is further removed by the process of coagulation and flocculation using lime and ferrous sulphate in the chemical treatment process in flask mixer tank at Stage - II[23]. The toxicity of the treated effluent in this stage had decreased to some extent increasing the fish 96hLC_{50} values. The solid sludge produced in the above process is removed using high pressure in the hydraulic press (CETP Stage - III). This process is used to remove the enormous solid sludge coagulated from the effluent along with the chemical constituents used in chemical treatment processes. In this process around 1.4g/L of secondary sludge is removed from the liquid part of the effluent. This had further decreased the fish 96hLC_{50} values. The toxicity of the effluent is finally reduced by disinfection using chlorine and finally purified in the dual media filter. The fish had atlast survived acute toxicity study. Thus the water may again need to be purified by using reverse osmosis for further use.

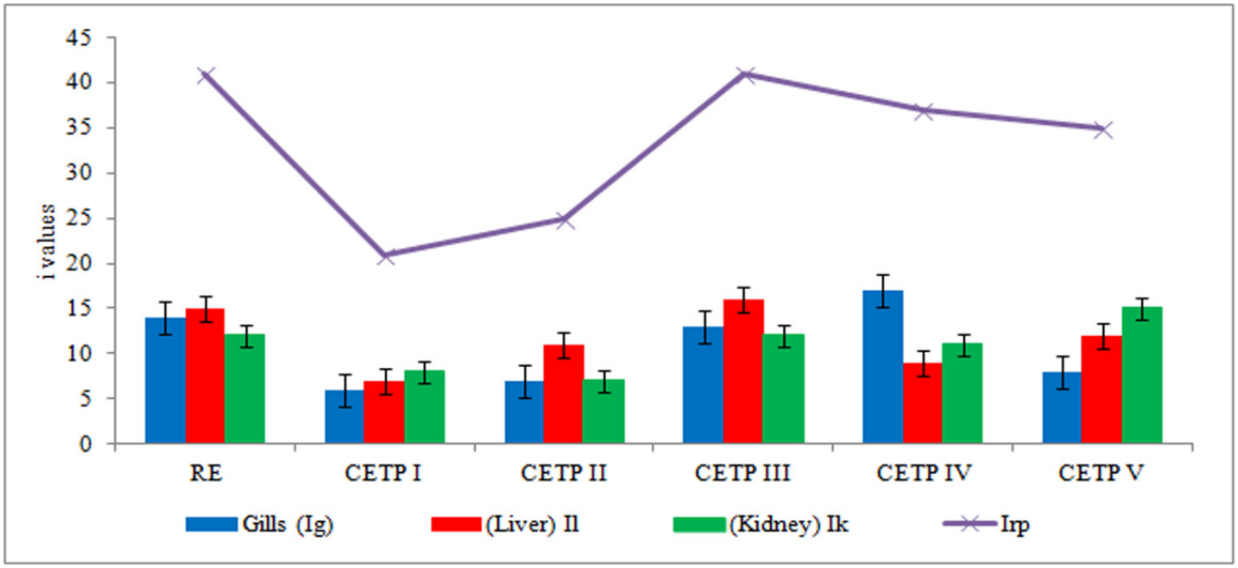

Figure-1: The individual (gills, liver and kidney) and total organ pathology indices in the fish population exposed to the Raw textile effluent (RE) and the subsequent effluent treatment stages adopted in CETP, SIPCOT.

Conclusion

The RE containing high physicochemical parameters were toxic to *Labeo rohita*. The treatment of the RE through each stages of CETP resulted in higher toxicity reduction and increase in fish 96hLC_{50} values. The chemical and bacterial treatments had decolourized the effluent with better reduction in effluent physiochemical parameters. Higher secondary sludge was produced due to high volume of chemicals used in the treatment processes, which is the main disadvantage in this treatment process. About 1.4g/L of secondary sludge is produced, which is filtered through hydraulic press. The toxicity of the effluent was further reduced by chlorination and filtration of the effluent which is indicated by increased survival time of the fish population in the treated effluent. As the fish population did not survive past acute toxicity, the reduction in effluent toxicity is only moderate. Hence the release of this treated effluent is unsuitable to be disposed off into any water body. The total recovery of the water with reduced physicochemical parameters after all treatment processes was 85%, and they can only be suitable for reuse in textile processing.

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