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Impact of Tannery Effluent on Wetland Birds of Dindigul District, Tamilnadu, India

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Abstract: Water and soil is the most important and crucial factor on the global ecosystems and human health. This study focuses on the physico chemical parameters of effluent water and soil serving as an indicator of Tannery effluent tank, in Dindigul District. Bird census made using total bird count from December 2009 to May 2012 to enumerate bird species composition in the Tannery effluent tank. The study area harbored totally 14 species of birds which is grouped under 9 families falls under 7 orders. The maximum abundance of birds species was from the family Ardeidae and Charadridae. The most dominant species in Tannery Effluent tank was Black-winged Stilt and Little Egret. Water bird species seen abundantly were Black-winged Stilt, Little Egret, Grey Duck and Green Shank. The least number of bird species observed was Large Egret, Little Grebe and Median Egret. Electrical conductivity, total dissolved solids and the level of Chloride, Sulphate, Iron, Ammonia, Nitrate, Phosphate, BOD, COD and DO were high in the effluent water. Fluoride and Nitrite was within the standard limit of effluent water. The accumulation of micro nutrient in soil as Manganese, Zinc, Copper and Iron were high during the study. Determining the bird community in Tannery Effluent Tank and to evaluate the impact of Tannery Effluent Tank on the distribution of birds in Dindigul and the results highlights the discharge of highly polluted waste water effluent from tanneries of Dindigul District.

Keywords: Tannery Effluent, Bird Species, Physico Chemical Analysis - Water, Soil, Dindigul

1. Introduction

Wetlands are defined as "areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions [1].

Avian community studies are effective tools for monitoring a pond ecosystem. Wetlands constitute a treasury of economic reserves and provide the right kind of habitats for breeding, nesting, mounting and wintering of local and migratory birds. Such sites also provide fodder and forage for many animals including birds and have aesthetic values as well. The relationship between wetlands and birds is shaped by many factors. These include the availability of depth and quality of water and the availability of food [2] and shelters and the presence and absence of predators. Water birds play an important role in several spheres of human interest, culturally, socially, scientifically and as a food resource [3].

Many studies have suggested that the combination of variable topography with suitable water depth provides habitats accessible for diverse water birds [4, 5 and 6] Ponds with gentle sloping sides can also increase topographical variation and attract both short and long legged wading birds [7].

In addition to the habitat variables, other variables related to the characteristics of sediments (organic matter content and particle size) and water quality such as temperature, Dissolved Oxygen, N, P, K, Mn, Zn, Cu, Fe, and pH can also directly or indirectly affect the use of wetlands by water birds. The organic matter content in water and sediments affects the growth of aquatic plants, and determines invertebrate abundance [8]. Particle size of sediments determines how water and oxygen penetrate sediments and thus affects the presence of microfaunal and avifaunal invertebrates [9]. Kersten *et al.,* [10] have demonstrated that the dissolved oxygen in the water affects the foraging of

water birds by changing the vertical distribution of prey.

Industrial wastes, agriculture wastewaters, runoffs and atmospheric deposition are major sources of contamination of many surface waters. Runoffs cause sedimentation problems [11] in receiving streams, rivers and lakes. They can also transport toxic pollutants into catchments [12] with potential transfer to the food chain. Good quality water resources are of becoming more and more scarcity of conventional water resources, due to water demand increases both for human consumption and for agricultural use, the reuse of saline, brackish, and treated waste water could be a realistic way for reducing water shortage, as it has been demonstrated in many countries in the Mediterranean basin [13]. Effluent differs from fresh water for salinity, pH and concentrations of micro- elements and nutrients. Lakhiwal and Chauhan, [14] studied the physico-chemical parameters of tannery effluent water and its applicability to irrigation.

Many different types of pollutants, if added to soil and soil are in direct contact with water, the ultimate fate of a pollutant will have its direct impact on the soil and agricultural land. In this back ground, it becomes necessary to study the soil that mostly degraded by tannery effluents [15].

Tanning is a major polluter worldwide and tannery wastewater, in particular, is a potential environmental pollutant [16]. Water pollution by tannery wastes in Tamil Nadu is very severe and there is large number of tanneries in the state and the wastewater from the industry has caused considerable damage to water sources, affecting drinking water supply and irrigation. Dindigul district is one of the important tanning centres in Tamil Nadu with 60 registered tanning industries. Due to lack of integration of environmental considerations in the development of this region, the fast growth of the tanning industry in this belt has resulted in a drastic change in the environment. The tanneries which do not have effluent treatment plants discharge the untreated effluents laden with salts and other pollutants like chromium, lead etc. in large amounts indiscriminately in to the open lands, pits, channels, tanks and in low-lying areas. Lagooning of tannery wastes, or spreading on land for evaporation, together with the solid wastes has led to the contamination of ground water, which is the only source for drinking water and irrigation.

Thus the present investigation was designed to analyze the Physico chemical parameters of tannery effluent water and soil and to enumerate the bird's species composition in tannery effluent tank, Dindigul district.

2. Methodology

Bird Census

The bird census was taken from December 2009 to April 2010. The method of total count was employed to survey the bird population [17]. In this method, the blocks were identified and the bird in the blocks were counted using a (7x50) pentax binocular and identified using physical features with the help of field guild [18, 19]. Birds were recorded during the study period. The census was made thrice a month.

Vegetation

The vegetation of the area was studied by identifying the plants. Specimens may be collected when they are in flower or fruit and preserved for identification with the help of books or some botanists for later reference.

Aquatic plants and succulents may be stored in liquid medium of either 5% formaldehyde or 70% alcohol. Dried herbarium specimen is to be stuck onto the herbarium sheet using gum / glue and thicker specimen may be tied to the sheet by a thread. Label is to be affixed on to the sheet by recording name of plant, details of the flower, habitat and plant associations, collection number and collector's name.

Birds Population and Distribution

Birds of the wetland may be identified upto species and counted separately. The total counts being made by walking along the trail stopping at specific points and combing a particular area viewing through a binocular pentax 20x50 PCF. Care should be taken to avoid overlap. Birds flying from area to the other should also be noted in order to minimize error while compiling the data. Such count may be conducted thrice a month and recorded for analysis.

Analysis of water and soil samples

The water was collected once in a study period and the soil samples were collected once in a month immediately after the bird census in order to facilitate comparison of bird count with water and soil characteristics. Techniques used to measure the different variables are using standard methods as follows.

Water quality analysis such as temperature, pH, acidity, alkalinity, and chloride were analyzed by volumetric means, the macro and micro elements were analyzed in laboratory as per the standard methods (APHA, 2005). Overall results were subjected to statistical analysis of mean and standard deviation.

Statistical Analysis
Species Richness and Abundance

Characterization of a community in a simple way is to count the various species recoded is expressed as species richness. Species abundance was measured by number of water birds species recorded from the habitat during census [20]. The total number of birds recorded divided by number of counts conducted is expressed as the average number of birds and it is considered as the abundance of birds.

Species Richness

The Richness of bird species was calculated using the margalef [21] index.

$$R_1 = (S - 1) / Ln (n)$$

Where,

S = The total number of species

N = The number of individuals.

Species Diversity

Species diversity was calculated using the Shannon –

Weaver index (Shannon Weaver [22].

$$H1 = - \Sigma \, Pi \times Ln \, (Pi)$$

Where,

Pi = The proportion of individuals found in the 1th species.

$$Ln = Log \, normal$$

Evenness Index
A number of indices have been used to quantify evenness. Component of diversity

$$E1 = H^1 / Ln \, (S)$$

Where,

H^1 = Diversity

Ln = Log normal

S = Number of Species

Commonness Index
The commonness of each bird species in habitat was found out by calculating

Commonness index, which is the average sighting frequency of a species in one.

Dominance Index
The relative dominance of each bird species in the habitat was determined by calculating dominance index using the following formula

$$Relative \, dominance = n_1 \times 100 \, / \, N$$

Where,

N1 = Number of individual in 1th species

N = Means the total number of individual of all species.

Seen during the study period.

3. Result and Discussion

A study was conducted from December 2009 - May 2012 to enumerate the bird species composition in the tannery effluent tank. A total of 14 species represented, 7 orders of 9 families were observed. The results showed that the most dominant bird species were Black-winged Stilt followed by Little Egret, Grey Duck and Greenshank. The rarest bird species were Pond Heron, Little Cormorant, Spotted Redshank, Common Sandpiper, Red-rumped Swallow, Painted Stork and Grey Patridge.

The number of species was high in January and December. The least number of bird species was observed during the month of April and March (Figure 1). Bird abundance was high in February and low in April. High abundance in February was due to the high water inflow and incoming of migratory bird (Figure 2). The same result was reported by Vijayan [23] and Meena [24].
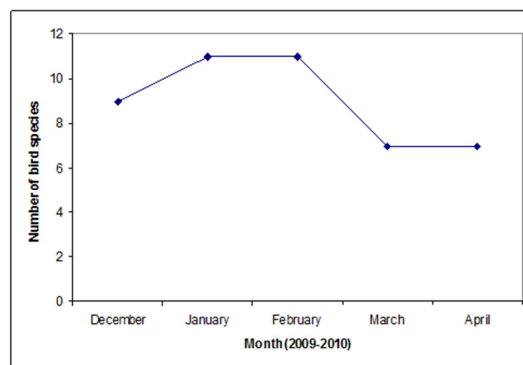

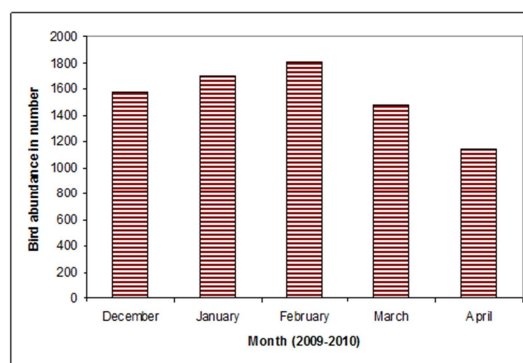**Fig. 1.** *Species richness in Tannery effluent tank during 2009-2010.*

Fig. 2. *Abundance of bird species in Tannery effluent tank during 2009-2010.*

The number of species was high in December and low in March during 2010-2011 (Figure 3). The maximum species richness was observed in December and the minimum species richness was observed in January, February and March (Figure 4).
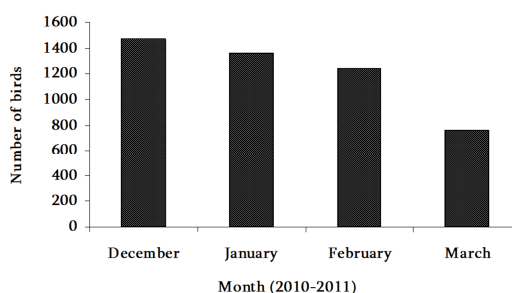

Fig. 3. *Species richness in Tannery effluent tank. during 2010-2011.*
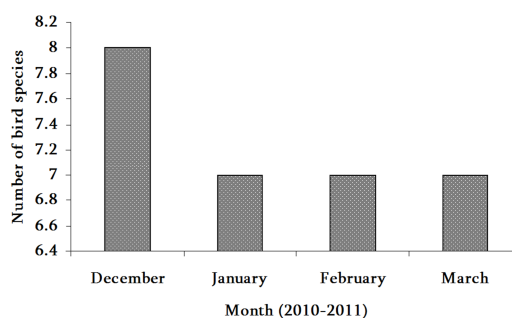

Fig. 4. *Abundance of bird species in Tannery effluent tank during 2010-2011.*

The maximum species richness was observed in December, January, February and March (Figure 5), because of the availability of prey categories as in the study of Nilsson [25]. The species richness was very low in April and May, and this is because of low water level [26]. The number of bird species was high in December followed by January and February. The least number of bird species was observed during the month of April and May. Bird abundance was high in December followed by January and February. The abundance was very low in April and May (Figure 6) due to the high inflow of effluent water and migrant bird species. The same result was reported by Nazeema and Nirmala [27].
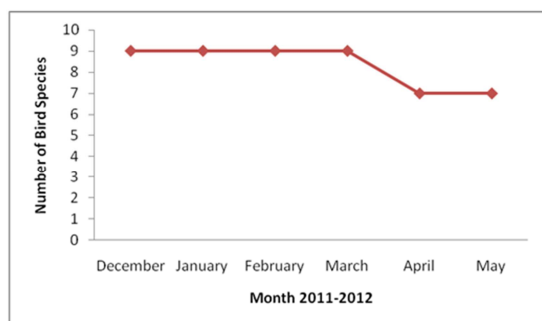

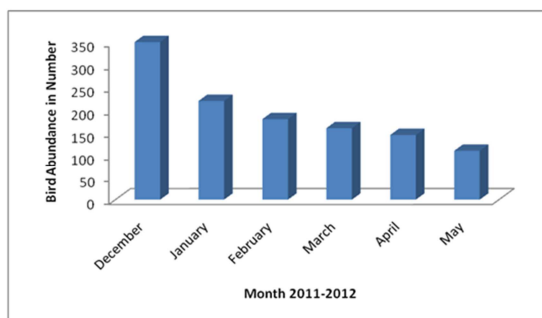**Fig. 5.** *Species richness in Tannery effluent tank during 2011-2012.*

Fig. 6. *Abundance of bird species in Tannery effluent tank during 2011-2012.*

The Bird species diversity was high in December with high evenness or equitability recorded in December and the minimum in April (Figure 7 & 8). This showed that the species there equally distributed in December than in January. Diversity was low in April with lowest equitability Nirmala and Nazeema, [28].
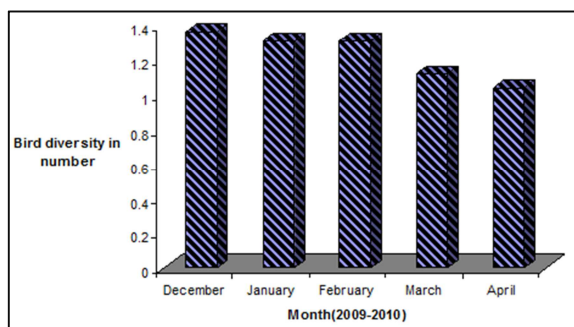

Fig. 7. *Diversity of Bird species in Tannery effluent tank during 2009- 2010.*
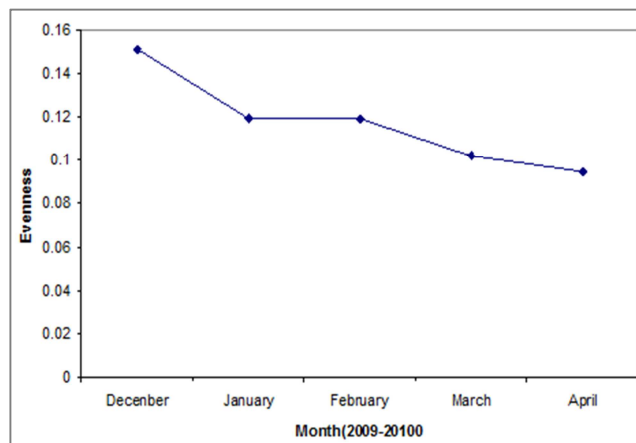

Fig. 8. *Evenness of Bird species in Tannery effluent tank during 2009- 2010.*

Diversity indices are dependent on two factors, species richness and evenness. In tannery effluent tank, the diversity of wetland bird species was high in December and low in February and March (Figure 9). Evenness was high in December and low in January.
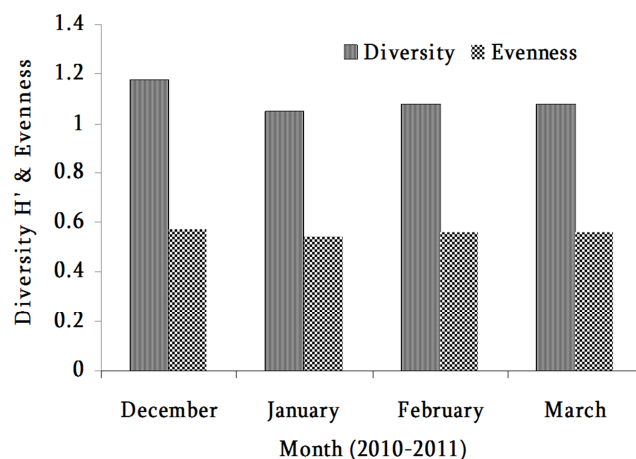

Fig. 9. *Diversity and Evenness of Bird Species in Tannery Effluent Tank during 2010- 2011.*
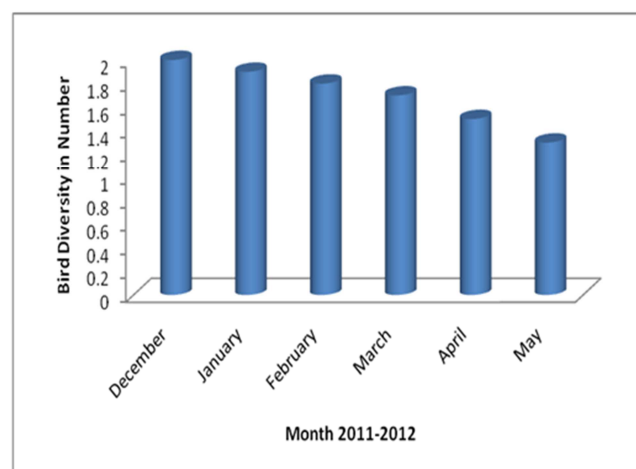

Fig. 10. *Diversity of Bird Species in Tannery effluent tank during 2011-2012.*
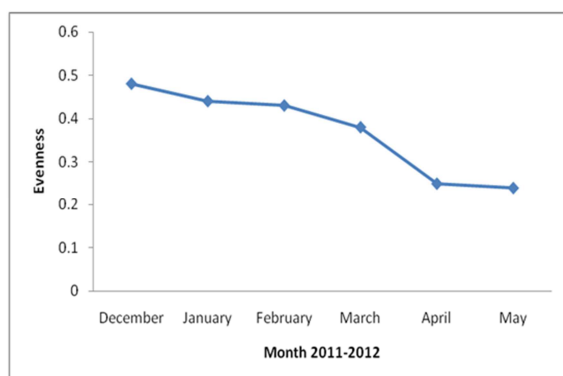
Fig. 11. *Evenness of bird species in Tannery effluent tank during 2011-2012.*

The bird species diversity was high in December with high evenness or equitability and the minimum during May (Figure 10 & 11). This showed that this species is equally distributed in December than January.

3.1. Avifauna of Tannery Effluent Tank

Tannery effluent tank holds fourteen number of species during 2009 to 2012. The order Ciconiiformes followed by Charadriiformes hold high number of bird species and Ardeidae was the family share more number of bird species in Tannery effluent tank (Table 1). Pelecaniformes, Anseriformes, Passeriformes, Galliformes, Podicipediformes shared only one species in this area.

Table 1. *Avifauna of Tannery Effluent Tank during 2009-2012.*

Order	Family	Common Name of the Birds Species	Scientific Name
Pelecaniformes	Phalacrocoracidae	Little Cormorant	*Phalacrocorax niger*
	Ciconiidae	Painted Stork	*Mycteria leucocephala*
		Little Egret	*Egretta garzatta*
Ciconiiformes	Ardeidae	Pond Heron	*Ardeola garyii*
		Median Egret	*Egretta Intermedia*
		Large Egret	*Casminodius Albus*
Anseriformes	Anatidae	Grey Duck	*Anaspoecilorhyncha*
	Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*
Charadriiformes	Scolopacidae	Spotted Redshank	*Tringa erythropus*
		Green Shank	*Tringa nebularia*
	Charadridae	Common Sandpiper	*Tringa Hypoleucos*
Passeriformes	Hirundinidae	Red-rumpedSwallow	*Hirundo daurica*
Galliformes	Phasianidae	Grey Patridge	*Francolinus pondicerianus*
Podicipediformes	Podicipedidae	Little Grebe	*Tachybaptus Ruficolis*

3.2. Common Species in the Tannery Effluent Tank

The Black-winged Stilt was the most common species followed by Little Egret and Grey duck of Tannery Effluent Tank. The least common species were Median Egret followed by Grey Patridge and Pond Heron (Table 2) which has the commonness index below 10.

Table 2. *Common Bird Species in the Tannery Effluent Tank during the study period 2009-2012.*

S. No	Birds Name	Commonness Index During 2009-2012
1	Black-winged Stilt	986.83
2	Little Egret	701.46
3	Grey Duck	198.91
4	Greenshank	52.42
5	Common sandpiper	30.78
6	Red-rumped Swallow	28.26
7	Little Cormorant	25.28
8	Little Grebe	17.52
9	Large Egret	15.41
10	Spotted Redshank	13.27
11	Painted Stork	8.18
12	Pond Heron	2.89
13	Grey Patridge	1.47
14	Median Egret	0.25

3.3. Dominant Bird Species in the Tannery Effluent Tank During the Study Period 2009-2012

The most dominant species in the Tannery effluent tank were Black-winged Stilt followed by the Little Egret and Grey duck. The least dominant bird species were Spotted red shank, Pond Heron and Grey Patridge. (Table 3) which has less than 10 as their dominant index.

Table 3. *Dominant Bird Species in the Tannery Effluent Tank during the study period 2009-2012.*

S. No.	Birds Name	Dominance Index During 2009-2012
1	Black-winged Stilt	125.74
2	Little Egret	82.32
3	Grey Duck	34.09
4	Median Egret	14.74
5	Little Cormorant	11.96
6	Little Grebe	10.34
7	Large Egret	9.09
8	Greenshank	3.08
9	Painted Stork	3.08
10	Red- rumped Swallow	2.23
11	Common sandpiper	2.00
12	Spotted Redshank	1.01
13	Pond Heron	1.01
14	Grey Patridge	0.09

3.4. Physico Chemical Analysis of Water in Tannery Effluent Tank

From the results, the colour of the water sample from tannery effluent was brownish during 2009 and later it was black in color during 2012 (Table 4). The colour is the first contaminant that has to be recognized in waste waters which affects the aesthetics, water transparency and gas solubility of water bodies [29]. Wastewater that is light brown in colour is less than 6 hours old, if the colour is dark grey or black, the wastewater is typically septic, having undergone extensive bacterial decomposition under anaerobic conditions. The blackening of wastewater is often due to the formation of various sulphides, particularly, ferrous sulphide [30].

Although the turbidity in 2012 was lower than that recorded in 2009, both are exceedingly high from the acceptable limit (Table 4). The electrical conductivity (EC) of the water sample was 15,000 mg/l during 2009 and the value exceeded to 23300 mg/l during 2012. The Increase of EC value indicated the presence of higher concentration of ions. Kaushik [31] reported that EC of Anantpur samples being too high when compared to Sansarpur samples. Sivakumar et al., [32] observed lower electrical conductivity in Dindigul effluent sample than in Ambur district.

Total dissolved solids in the effluent water sample were higher than the acceptable limit (Table 4). Large fluctuations in total solids (i.e., 8000 to 76, 500 mg/l) of tannery effluent water was reported by [33; 34; 35; 36 and 37]. The total dissolved solids may increase salinity of the water and thus may render it unfit for irrigation and drinking purposes. Consumption of water with high concentrations of total dissolved solids has been reported to cause disorders of alimentary canal, respiratory system, nervous system, coronary systems, besides causing miscarriage and cancer [38].

The PH was found 7.6 during 2009 and 7.9 during 2012 within the acceptable limit in the Dindigul tannery effluent tank (Table 4). It is Alkaline. It is the capacity of waste waters to neutralize acids, and is undesirable [39]. The discharge of waste water in to water bodies may cause a drop or increase their PH. Alkalinity of tannery effluent water was 800 mg/l during 2009 (Table 4). Simillar observations were made by Sakthivel and Sampath [40] in Dindigul.

Total hardness remains the same (2500 mg/l) during the study. High amount of calcium was observed in 2009 (Table 4) where as the magnesium was high in 2012. Vasanthy and Sangeetha [41] reported higher values of total hardness and magnesium in tannery effluent at Trichy. The presence of Calcium, Magnesium in excess makes water unfit for irrigation since its application increase problems of soil salinity [42].

Table 4. Physico Chemical Examination of Water Sample from Dindigul Tannery Effluent Tank in 2009-2012.

Physical Examination	Acceptable Limit (mg/l)	Exceeding Limit (mg/l)	Dindigul Tannery Water (mg/l) in 2009	Dindigul Tannery Water (mg/l) in 2012
Appearance	-	-	Brownish	Black
Turbidity	2.5	10	660	296
Electrical Conductivity Micro mho/cm	-	-	15, 000	23300
Total Dissolved Solids mg/l	500	2000	10,500	22500
Chemical Examination				
Alkalinity as $CaCO_3$	-	-	800	1600
PH	7.0 – 8.5	6.5 – 9.2	7.6	7.9
Total Hardness	200	600	2500	2500
Calcium as Ca	75	200	600	440
Magnesium as Mg	30	150	240	260
Iron as Fe	0.1	1.0	1.0	10
Manganese as Mn	0.05	0.5	0.1	0
Ammonia as NH_3	-	-	10	60
Nitrate as NO_3	100	100	30	57
Nitrite as NO_2	-	-	0.5	2
Fluoride as F	1	1.5	0.4	1.2
Biological Oxygen Demand	-	-	500	70
Chloride as Cl	200	1000	4750	8500
Dissolved Oxygen	-	-	1	10
Sulphate as SO_4	200	400	400	900
Phosphate as PO_4	-	-	0.5	25
Tidys Test (4hours) as O_2	-	-	4	25.0
Chemical Oxygen Demand	-	-	1400	150

The level of Chloride, Sulphate and Phosphate was much higher in 2012 than in 2009 (Table 4). Excess outflow of the toxic effluent will make the water body unfit for plants and other living organisms [32].

The level of Iron, Ammonia, Nitrate, Fluoride and Nitrite in the effluent was high in 2012 where as it was low in 2009. Fluoride and Nitrite was within the standard exceeding limit of effluent water (Table 4).

Dissolved oxygen (DO), was found high (10 mg/l) during 2012 and it was low in 2010. This is in par with the observation made by Nanda Kumar et al., [43]. The high Biological Oxygen Demand levels are indications of high pollution. The BOD value was high in 2012 than in 2010. The high BOD and low oxygen content of tannery waste

water will affect survival of gill breathing animals of the receiving water body [44].

The values of COD from tannery effluent water was high in 1400 mg/l and 150 mg/l it was low in 2012 (Table 4). High COD levels indicate toxic state of the waste water along with presence of biologically resistant organic substances [45], Sivakumar *et al.*, [32] reported high level of COD which was higher than the standard prescribed limit of Central Pollution Control Board (1995).

3.5. Soil Analysis

High PH was observed in 2010 and it was low in 2011 (Figure 12). The electrical conductivity was high during 2009 followed by 2010 and it was low in 2011. The concentration of Nitrogen was higher in 2009 and lower in 2010. The Phosphorous was high in 2011 and low in 2009. The Potassium value was high during 2009 and it was comparatively low in 2010 and 2011 (Figure 13).
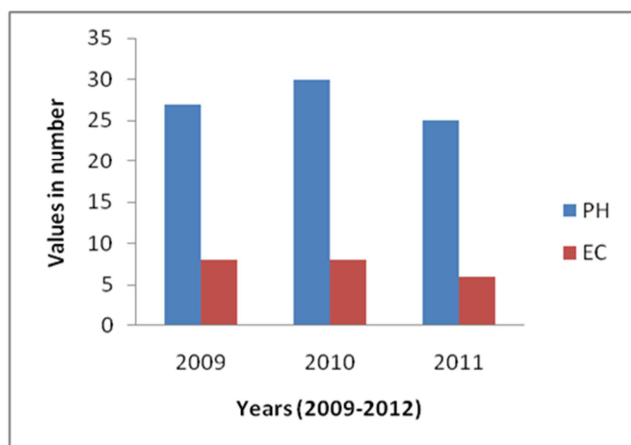

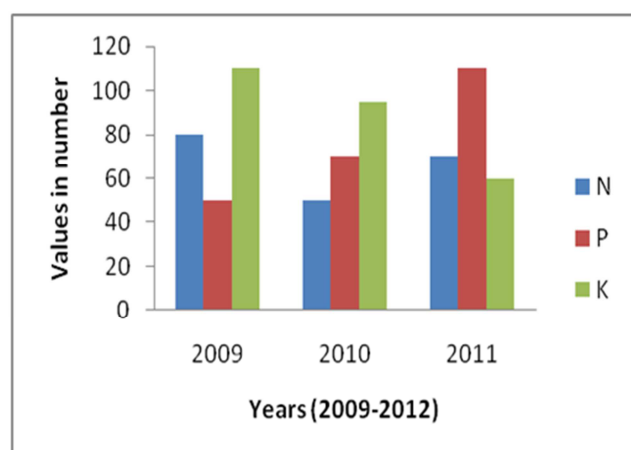*Fig. 12. Soil PH and EC Values from Tannery effluent tank during 2009-2012.*

Fig. 13. Soil N, P, K Values from Tannery effluent tank during 2009-2012.

The accumulation of micro nutrient as Manganese, Zinc, Copper and Iron were high during 2009 followed by 2011 and 2010 (Figure 14).
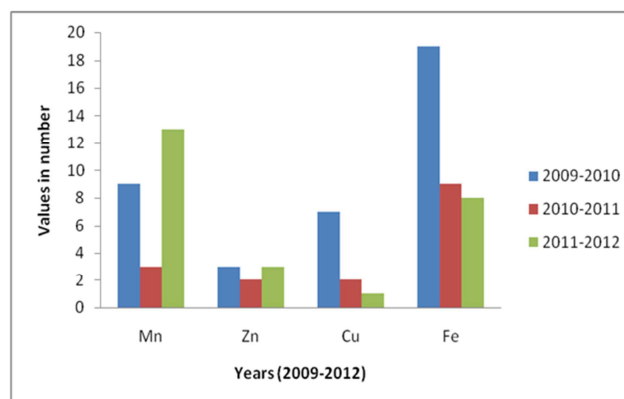

Fig. 14. Soil Mn, Zn, Cu, Fe Values from Tannery effluent tank during 2009-2012.

Therefore the resultant tannery effluent is found to be highly concentrated with heavy metals. When these tannery effluents percolate the sediments gets contaminated. Beg and Ali [46] reported that the highly polluted sediments are adversely affected the ecological functioning of rivers due to heavy mobilization from urban areas into biosphere. The present finding indicates that the soil irrigated with tannery effluent and industrial wastewater contained high levels of metallic pollutants. It is evident from these studies that the test sample from tannery tank responded to the long term application of industrial waste water by an resistance to several undesirable agents and maintained physiological traits.

4. Conclusion

The Physico – Chemical Parameters of tannery effluent water and soil were high throughout the study period. Thus from the above studies the analysis of tannery effluent water was highly polluted. This is because of the industries discharging the waste water without proper treatment and this in turn affect the organism in and around Dindigul District. The results of the present investigation point out the need to implement common objectives, compatible policies and programmes for improvement in the industrial waste water treatment methods.

Acknowledgement

References

[1] W. J. Mitsch, and J. G Gosselink "Wetlands". Second Edition Van Nostrand Reinhold, New York, NY. 1993, pp. 722.

[2] Sampath and Krishnamurth "Studies on the Ecology of Shore Birds, Aves, Charadriformes". Ph.D. Dissertation. Center of Advanced Study in Marine Biology Annmalai University, Parangipettai, Tamil Nadu, India. 1989.

[3]   E. A. Jayson "Avifauna in the Wetlands of Kerala". In Wetland Conservation and Management in Kerala. State Committee on Science, Technology and Environment Thiruvananthapuram, 2002.

[4]   M. A. Colwell., W. Taft "Water bird communities in Managed Wetlands of varying water depth". Waterbeds vol. 23, 2000, pp 45–55.

[5]   C. R. Isola., M. A. colwell., O. W. Taft., R. J. Sajran "Interspecific differences in habitat use of shorebirds and waterfowl Forging in managed wetlands of californias San Joaquin valley", waterbirds vol. 25, 2002, suppl. 2: pp. 196–203.

[6]   O. W Taft., M. A. Colwell., C. R. Isola., and R. J. Safran "Water bird responses to Expreimental drawdown: implication for multispecies management of wetland mosaics". Journal of Applied Ecology vol. 39, 2002, pp. 987–1001.

[7]   R. M. Erwin., J. S. Hatfield., M. Q. Howe., S. S. Klugman "Water bird use of saltmarsh ponds created for open water mash management". Journal of wildlife management vol. 58, 1994, pp. 516–224.

[8]   M. M. Rehfish "Man – Made lagoons and how their attractiveness to waders might be increased by manipulating the bio mass of and insect benthos" – Journal of Applied Ecology vol. 31, 1994, pp. 383–401.

[9]   C. Little "The biology of soft shores and estuaries". Oxford University press, Oxford, 2000.

[10] M. Kartsen, R. H. Britton., P. J. Dugan., H. Hajner "Flock feeding and food intake in Little Egrets: the effects of prey distribution and behavior". Journal of Animal Ecology vol. 60, 1991, pp. 241–252.

[11] K. Karlsson., M. Viklander., L. Scholes., M. Revitt "Heavy metal concentration and toxicity in water and sediment from storm water ponds and sedimentation tanks". J. Hazard, Mater. vol. 178, 2010, pp. 612–618.

[12] P. Globel., C. Dierkes., W. G. Coldewey "Strom water runoff concentration matrix for urban areas". Journal. contam. Hydrol. vol. 91, 2007, pp. 26-42.

[13] Saida Bedbabis, Béchir, Ben, Raina, Makki Boukhris, and Giuseppe Ferrara "Effects of Irrigation with Treated Wastewater on Root and Fruit Mineral Elements of Chemlali Olive Cultivar", Journal of Environmental Management. Vol. 133, 2014, pp. 45-50.

[14] Sunita Lakhiwal and Surendra Singh Chauhan "Seasonal Study of Physico-Chemical Parameters of Secondary Treated Waste Water From Delawas Sewage Treatment Plant". International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization) Vol. 4, Issue 7, July 2015.

[15] S. Vasantha kumar., and N. Vaani Gis "Based modeling of soil contamination –A threat to agriculture by dindigul Tanneries". Poll Res vol. 27, 1, 2008, pp. 113–116.

[16] M. Ros., and A. Ganter "Possibilities of reduction of recipient loading of tannery waste Slovenia". Water sci. technol. vol. 37, 1998, pp. 145–152.

[17] J. E. Hoves., D. Bakewell. "Shore Bird studies Manual" AWB publications. No. 55, Kolalumbur. 1989, pp 362.

[18] S. Ali., and S. A. Ripley "The Handbook of the Birds of India and Pakistan" Compact Edition. Oxford University Press, 1983, New Delhi.

[19] T. Inskipp, R Grimmett, and Inskipp Birds of Indian Subcontinent. Oxford University Press, (1998), pp 888.

[20] J. Verner Assessment of counting Techniques, in Johnston, R. F (Ed) current ornithology, New York: Plenum Press 1985, Pp 247–392.

[21] D. R. Margalef Information theory in ecology, Gen. Syst., 1958, 3, Pp 36–71.

[22] C. E. Shannon, and W. weaver, The mathematical theory of communication urban 1, 11: Illinois University press 1964.

[23] Vijayan "Keoladeo National Park Ecology, Study –Final Report 1980 -1990". Bombay National History Society, Bombay. 1991.

[24] S. Meena "Ecology of Water Birds Community in Thamaraikulam Pond at Ramasamynayakanpatti, Theni", M. Sc thesis. 2007.

[25] Nilsson. "Local Distribution, Food Choice and Food Consumption of Diving Ducks on a South Sweddish Lake". Oikos vol. 23, 1978, PP. 82-91.

[26] J. G. Gosselink The Ecology of Data Marshes of Coastal Louisia: 9 Community Profile FWS /0133. 81/24, Washington, De; USFSIH and Wild Life Service 1984.

[27] M. Nazeema and T. Nirmala "wetland birds species composition in tannery effluent tank, Dindigul, Tamilnadu, India". International Research Journal of Environment Sciences Vol. 4, 5, 2015, pp. 34-41.

[28] T. Nirmala and M. Nazeema "Analysis of Tannery Effluent with Special Reference to Avifauna" LAP LAMBERT Academic Publishing, 2015, PP. 11-25.

[29] W Yuxing., and Y. Jian "Decolorizaiton of Synthetic Dyes and Wastewater from Textile Water Research" vol. 33, 16, 1999, PP. 3512-3520.

[30] C. C. Sawyer., and P. L. Mccarty "Chemistry for Environmental Engineers". Mcgraw Hill, New york. 1987, PP. 331-514.

[31] S. Kaushik "Biosorption of Heravalent Chromium using Bacterial Isolates". M. phil. Dissertation. School of Energy and Environment Studies, Devi ahilya vishwavidalaya, Indore, 2003.

[32] P. Sivakumar., M. Kanagappan and S. Sam Manohar Das "Physico Chemical Characteristics of untreated effluent from Tannery Industries in Tamil Nadu": A comparative study, Int. J. Pharm Bio. Sci. vol. 6, 1, B, 2015, pp. 446-451.

[33] C. A. Sastry "Characteristics and Treatment of Wastewater from Tanneries". Indian Journal of Environmental Protection. vol. 6.3, 1986, PP. 159-168.

[34] V. P. Dikshit., and N. P. Shukla "Waste Recycling and Pollution Control in Indian Tanneries". Indian Journal of Environmental Protection vol. 9, 3, 1998, PP 182-186.

[35] A. Shukla., and N. P shukla "Tannery and Electroplating Effluent Treatment – Precipitation of Chromium and Nickel". Indian Journal of Environmental Protection vol. 14, 6, 1994, PP. 457–461.

[36] V. Mariappan, and M. R. Rajan "Environmental Impact of Tannery Hazards in Dindigul City of Tamilnadu". Environment and People vol. 11, 4, 2004, PP. 26-29.

[37] M. Vasanthi., and M. Sangeetha "Effective Heavy Metal [cr (vi)] Removal using Bacterial Strains". Indian Journal of Environment and Ecoplanning vol. 8, 3, 2004, PP. 787-792.

[38] P. M. Reddy., and N. Subba Rao "Effects of Industrial Effluents on the Ground Water Regime in Vishakapatnam". Pollution Research vol. 20, 3, 2001, PP. 383-386.

[39] R. K Trivedy., and P. K Goel "Chemical and Biological Methods for the Water Pollution Studies". Environment Publication, Karad. 1986.

[40] M. Sakthivel., and K. Sampath "Respiration of Blood Cells and Food Conversion Efficiency in *Cyprinus carpio* Exposed to Sublethal Concentrations of Tannery effluents. in Deshmukh" P. B., Mathai A. T., Dalela R. C., and Pillai K. S. Eds, Environment and Experimental Toxicology, Jai Research Foundation, Valvada. 1990, PP. 139-150.

[41] M. Vasanthi and M. Sangeetha Effective Heavy Metal [cr (vi)] Removal using Bacterial Strains. Indian Journal of Environment and Ecoplanning 8, 3, 2004, PP 787-792.

[42] M. Srinivas., G. Teekaraman., and N. Ahmed Farooque. "Ground water Pollution due to Tannery Effluents in North Arcot District, Tamilnadu". Indian Journal of Environmental Health vol. 26, 4, 1984, PP. 314-322.

[43] N. V. Nanda Kumar K. Bhagualakshmi, and M. Dhananjaya Naidu "Tannery and Chromate Industrial Effluent and Pesticide Contamination of Reservoirs and Other Water Bodies: Physico-Chemical and Ecotoxicologcal Studies". In: Mishra P. C., and Privedy R. K. Eds, Ecology and Pollution of Indian Lakes and Reservoirs Ashish publishing house, New Delhi, 1993, PP. 269 -291.

[44] R. O Yusuff., and J. A "Sonibare Characterization of Textile Industries Effluent in Kaduna", Nigeria and Pollution Implications, Global Nest: The International Journal vol. 6, 3, 2004, PP. 211-220.

[45] C. N Sawyer., P. L McCarty "Chemistry for Environmental Engineering" 3rd ed., McGraw-Hill, Singapore, 1989.

[46] K. R. Beg., and S. Ali "Chemical contaminants and Toxicity of Ganga River Sediment from Up and Down stream Area at Kanpur". American Journal of Environmental Sciences vol. 4, 2008, pp. 362–366. ISSN 1553–345 X.