International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(4): 1937-1940

Received: 01-05-2017
Accepted: 02-06-2017

Priyadharshini M
Department of Environmental Sciences, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

C Udayasoorian
Dryland Agricultural Research Station, Tamil Nadu Agricultural University, Chettinad, Tamil Nadu, India

Correspondence
Priyadharshini M
Department of Environmental Sciences, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Characterization and assessment of paper mill effluent for physico-chemical and biological properties and assessment for the suitability as a source of irrigation

Priyadharshini M and C Udayasoorian

Abstract
The present investigation was carried out during 2009-2010 to characterize and assess the treated paper mill effluent from The Tamilnadu Newsprint and Papers Limited (TNPL) for physico-chemical and biological properties. Treated paper mill effluent samples were collected from TNPL, Kagithapuram, Karur District of Tamil Nadu and were analyzed in the Department of Environmental Sciences, Tamil Nadu Agricultural University, Coimbatore. The paper mill effluent collected from TNPL, Karur was light brown in colour. The effluent was found to be neutral in reaction with a pH of 7.61. It recorded an EC of 1.68 dS m^{-1} and organic carbon content of 0.48 per cent. The effluent had considerable amount of cations like calcium (236 mg L^{-1}), magnesium (32.5 mg L^{-1}), sodium (302 mg L^{-1}) and potassium (19.0.0 mg L^{-1}) along with anions like chloride (357.0 mg L^{-1}), bicarbonate (135.5 mg L^{-1}) and sulphate (85.2 mg L^{-1}), respectively.The BOD and COD values of treated effluent were 26.0 and 235 mg L^{-1}, respectively.The paper mill effluent supported a considerable amount of microbial population. In general, the major quality parameters analyzed *viz.*, pH, EC, TDS, BOD, COD, chloride and sulphate values of treated effluent were observed to be well within the permissible limits as prescribed by the TNSPCB (Tamil Nadu State Pollution Control Board) norms. From the present study, it is concluded that the treated TNPL effluent complies with TNSPCB norms and could be used for irrigation in light textured dry land soils with adequate drainage facilities.

Keywords: Solid and liquid wastes, paper mill effluent, pollution, physico-chemical properties

Introduction
Many industries produce large volume of effluents requiring proper disposal. Lack of suitable technologies and disposal facilities are the major limitation to industrial expansion. Industries mainly focus on the fulfillment of needs and necessities of the modern human being, which in turn, produces solid and liquid wastes. As an alternative, these solid and liquid wastes must be put into use for the production of other products, without qualitative degeneration of the environment.

In pulp and paper industry, 75 to 90 per cent water used for process is let out as wastewater, the effluent carrying dissolved solids and varying amount of suspended organic, inorganic pollutants and colouring materials. Moreover, it affects the physical conditions of the soil. There are about 600 paper mills in the country with an annual installed capacity of 8.5 million tonnes of paper. The average quantity of water consumed for each tonne of paper produced is about 300 m^3 and this amount reappears as effluent causing wide spread environmental pollution [1, 2].

In Tamil Nadu, there are 31 units with an installed capacity of 0.64 million tonnes per annum. The Tamilnadu Newsprint and Papers Limited (TNPL) situated at Kagithapuram, Karur District, the major paper industry in Tamil Nadu established in 1984, is producing 50,000 tonnes of Newsprint and 40,000 tonnes of writing paper every year. It has expanded its installed capacity to 2,30,000 from 1,80,000 t y^{-1} in 2003. It is drawing about 40,000 m^3d^{-1} of water from the Cauvery and discharging around 30,000 m^3d^{-1} of treated effluent.

Reuse of wastewater in agriculture is anticipated to increase dramatically in future as fresh water resources are becoming scarce and expensive as ground water is being depleted rapidly for various purposes. Application of effluent on land offers a promising option as irrigation water and source of plant nutrients while they offer solution to the disposal problems.

However, effluents of some industries have useful characteristics and have the potential to improve soil productivity [3]. Therefore, the present study was conducted to characterize and assess the treated paper mill effluent from TNPL for physico-chemical and biological properties.

Materials and Methods

The present investigation was carried out during 2009-2010 to characterize and assess the treated paper mill effluent from TNPL for physico-chemical and biological properties. Treated paper mill effluent samples were collected from TNPL, Kagithapuram, Karur District of Tamil Nadu. Solid wastes and effluent samples were analyzed in the Department of Environmental Science, Tamil Nadu Agricultural University, Coimbatore and the analytical methods followed are given below.

Collection of effluent samples

The effluent samples were collected from TNPL, Kagithapuram and analyzed for their physical, chemical and biological properties. Samples for microbial examinations were collected in sterilized bottles. The sampling bottles were closed with round glass stopper having an overlapping rim. The stopper was relaxed by an intervening strip of paper to prevent breakage of the bottle during sterilization. The stopper and neck of the flask or bottles were protected by covering them with aluminum foil and sterilized in an autoclave at 20 psi for 15 minutes. The bottles were then opened only at the time of sampling.

Those samples for the analysis of dissolved oxygen (DO) were added with one ml of manganese sulphate solution and one ml of alkaline potassium iodide solution as given under the procedure for the estimation of dissolved oxygen. Samples for the determination of Biochemical oxygen demand (BOD) were preserved by adding 5 ml of washed chloroform (Chloroform and distilled water layer were discarded) per litre of the sample [4].

Characterization of effluent samples

The physical, chemical and biological characteristics of the effluent samples were analyzed as per the methods detailed in the standard methods for the examination of water and wastewater (Table 1) [4].

Table 1: Standard methods followed for the analysis of paper mill effluent

Sl. No.	Parameters	Unit	Method	Reference
I	**Physical Properties**			
1	Colour	-	Using spectrophotometer and expressed in Platinum Cobalt colour units	[5]
2	Suspended solids	mgL^{-1}	A known quantity of the effluent was filtered using Whatman No.1 filter paper and the residue was dried at 105ºC to a constant weight	[5]
3	Dissolved solids	mgL^{-1}	The filtrate obtained from the suspended soilds was evaporated and dried at 105ºC to a constant weight	[5]
4	Total solids	mgL^{-1}	A known quantity of the effluent was evaporated and dried at 105ºC to a constant weight	[5]
II	**Chemical properties**			
5	pH	-	Measured using digital pH meter	[6]
6	EC	dSm-1	Measured using conductivity bridge (CM 180 Elico conductivity bidge)	[6]
7	DO	mgL^{-1}	Azide modification iodimetric method	[4]
8	BOD	mgL^{-1}	Incubation method	[5]
9	COD	mgL^{-1}	Refluxed for 2 hrs and titrated against 0.5N FAS using ferroin indicator	[5]
10	Organic Carbon	Per cent	Chromic acid wet digestion method	[7]
11	Ammonical nitrogen	mgL^{-1}	Bremner Method	[6]
12	Phosphorus	mgL^{-1}	Photoelectric colorimeter at 660 nm	[8]
13	Carbonates	mgL^{-1}	Titrating with 0.1N H_2SO_4 using phenolphthalein indicator	[9]
14	Bicarbonates	mgL^{-1}	Titrating with 0.1N H_2SO_4 using methyl orange indicator	[9]
15	Calcium	$mg\ L^{-1}$	Versenate titration method	[10]
16	Magnesium	$mg\ L^{-1}$	Versenate titration method	[10]
17	Sodium	$mg\ L^{-1}$	Flame photometer	[10]
18	Potassium	$mg\ L^{-1}$	Flame photometer	[10]
19	Chloride	$mg\ L^{-1}$	Mohr's method	[10]
20	Sulphates	$mg\ L^{-1}$	Turbidimeteric method	[10]
III	**Biological properties**			
21	Bacteria	$x\ 10^6\ CFU\ g^{-1}$	Nutrient agar	[11]
22	Fungi	$x\ 10^4\ CFU\ g^{-1}$	Martin's rose bengal agar	[11]
23	Actinomycetes	$x\ 10^3\ CFU\ g^{-1}$	Ken Knight's agar	[11]

Collection of solid wastes

The samples collected from TNPL were shade dried, sieved through 2 mm nylon mesh sieve and stored in polythene bags. The samples thus prepared were taken for physical, chemical and biological analysis as detailed in Table 2.

Table 2: Physico-chemical and biological analysis of solid wastes

Sl. No.	Particulars	Unit	Remarks	Reference
1.	pH	-	Sample: water suspension of 1:2.5	[6]
2.	EC	$dS\ m^{-1}$	Sample: water suspension of 1:2.5	[6]
3.	Organic carbon	Per cent	Wet digestion	[9]
4.	Total N	Per cent	Di acid extract	[6]
5.	Total P	Per cent	Tri acid extract	[6]

6.	Total K	Per cent	Tri acid extract	[6]
7.	Total Ca and Mg	Per cent	Versenate titration method	[6]
8.	Total Na	Per cent	Tri acid extract (EEL flame photometer)	[6]
9.	Bacteria	x 10^6 CFU g^{-1}	Nutrient agar	[11]
10.	Fungi	x 10^4 CFU g^{-1}	Martin's rose bengal agar	[11]
11.	Actinomycetes	x 10^3 CFU g^{-1}	Ken Knight's agar	[11]

Results and Discussion

Agro industrial wastes, being organic in nature, can be used in agriculture to increase the organic matter content of the soil. Apart from their nutritional value, these organic materials improve the physico-chemical properties of the soil and thereby increase the fertility and productivity of soils [12].

Characteristics of treated paper mill effluent

The important characteristics of paper mill effluent sample are furnished in Table 3. The paper mill effluent collected from TNPL, Karur was light brown in colour. The colour of the treated paper mill effluent used for irrigation is light brown in colour, which may be due to the presence of lignin and its derivatives formed during the pulping and bleaching process. The effluent had appreciable amount of suspended solids (161 mg L^{-1}), dissolved solids (1125 mg L^{-1}) and total solids (1286 mg L^{-1}).

The effluent was found to be neutral in reaction with a pH of 7.61. The neutral pH of the effluent was due to the use of lime to neutralize the effluent during its primary and secondary treatment processes. The electrical conductivity of the treated effluent was 1.68 dS $m^{-1}$and organic carbon content of 0.48 per cent which was due to the inorganic chemicals such as caustic soda, talc, rosin, etc. being used during the manufacturing process. The treated TNPL effluent has pH ranging from above neutral to alkaline (7.5 to 8.3) and electrical conductivity ranged between 1.28 and 1.36 dS m^{-1} [13, 14]. Similar findings have also been reported by [15, 16 and 17]. Similarly, the effluent had considerable amount of cations like calcium (236 mg L^{-1}), magnesium (32.5 mg L^{-1}), sodium (302 mg L^{-1}) and potassium (19.0.0 mg L^{-1}) along with anions like chloride (357.0 mg L^{-1}), bicarbonate (135.5 mg L^{-1}) and sulphate (85.2 mg L^{-1}), respectively. Such high sodium levels may result in the formation of diffuse double layer in the effluent irrigated soil [18]. The chloride content of treated effluent was 357.0 mg L^{-1} and it was well within the limit (600 mg L^{-1}) of the State Pollution Control Board (SPCB) [19].

The effluent had 3.42 mg L^{-1}dissolved oxygen which is in accordance with the findings of [20]. The BOD and COD values of treated effluent were 26.0 and 235 mg L^{-1}, respectively. High level of COD in the treated effluent could be attributed to the presence of chemicals like resin, alum and caustic soda. These findings are in line with [21] and [16]. The treated effluent had considerable amount of essential nutrients *viz.*, ammonical nitrogen, phosphorus and potassium.

Table 3: Characteristics of treated TNPL paper mill effluent

Parameters	Unit	Treated paper mill effluent
Physicalproperties		
Colour	-	Light brown colour
Total suspended solids	mg L^{-1}	161
Total dissolved solids	mg L^{-1}	1125
Total solids	mg L^{-1}	1286
Physico-chemical properties		
pH	-	7.61
Electrical conductivity	dS m^{-1}	1.68
Dissolved oxygen	mg L^{-1}	3.42
Biochemical oxygen demand	mg L^{-1}	26.0
Chemical oxygen demand	mg L^{-1}	235
Organic carbon	per cent	0.48
Carbonate	mg L^{-1}	BDL
Bicarbonate	mg L^{-1}	135.5
Calcium	mg L^{-1}	236
Magnesium	mg L^{-1}	32.5
Sodium	mg L^{-1}	302
Potassium	mg L^{-1}	19.0
Chloride	mg L^{-1}	357
Sulphate	mg L^{-1}	85.2
Biologicalproperties		
Bacteria	(x 10^6 CFU ml^{-1})	29.41
Fungi	(x 10^4 CFU ml^{-1})	16.33
Actinomycetes	(x 10^3 CFU ml^{-1})	12.58

BDL- Below Detectable Level

The paper mill effluent supported a considerable amount of microbial population *viz*., bacteria (29.41 x 10^6 CFU ml^{-1}), fungi (16.33 x 10^6 CFU ml^{-1}) and actinomycetes (12.58 x 10^6 CFU ml^{-1}), respectively which is in accordance with the findings of [22] and [13]. In general, the major quality parameters analyzed *viz.*, pH, EC, TDS, BOD, COD, chloride and sulphate values of treated effluent were observed to be well within the permissible limits as prescribed by the TNSPCB (Tamil Nadu State Pollution Control Board) norms.

Recycling the industrial wastes and using them in improving the soil fertility and consequently the crop production is a boon to the farmers. The present study clearly showed that the treated TNPL paper mill effluent can be used as an effective alternative source of irrigation and help in reducing negative

impact on environment. It is concluded that the treated TNPL effluent complies with TNSPCB norms and could be used for irrigation in light textured dry land soils with adequate drainage facilities. Further, to improve the yield and quality of various crops, different organic amendments can also be applied with the treated effluent as a source of irrigation.

Acknowledgement
The author is thankful to Department of Environmental Sciences, Tamil Nadu Agricultural University, Coimbatore and Tamilnadu Newsprint and Paper Limited, for the financial and logistics support to carry out the research.

References

1. Hazarika S, Talukadar NC, Borah K, Barman N, Medhi BK, Thakuria D *et al*. Long term effect of pulp and paper mill effluent on chemical and biological properties of a heavy textured acidic soil in Assam**.** J. Indian Soc. Soil Sci., 2007; 55(1)**:**45-51.
2. Toczylowska-Mamińska R. Limits and perspectives of pulp and paper industry wastewater treatment – A review. Renewable and Sustainable Energy Reviews. 2017; 78:764-772.
3. Kansal BD. Effects of domestic and industrial effluents on agricultural productivity. In: Management of agricultural pollution in India. (Eds) G.S. Dhalial and B.W. Kansal. Common Wealth Publishers, New Delhi, 1994, 157-173.
4. APHA. Standard methods for examination of water and waste water. American Public Health Association, Washington, USA, 1980, 83.
5. Gupta PK. Methods in Environmental Analysis: Water, soil and air. Updesh Purohit for Agrobios, Jodhpur, India, 2002, 125.
6. Jackson ML. Soil Chemical Analysis**.**Prentice Hall of India (Pvt.) Ltd., New Delhi, 1973, 109.
7. Walkl***e***y A, Black IA. An examination for the outline of method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci., 1934; 37:29-31.
8. Olsen SR, Cole LL, Watanabe FS, Dean DA. Estimation of available phosphorous in soils by extraction with sodium bicarbonate. U.S.D.A. - Cric. 1954**,** 939.
9. Piper CS, Soil and Plant Analysis. Inter Science Publications, New York**,** 1966, 368.
10. Jackson ML. Soil Chemical Analysis. Prentice hall of India (Pvt.) Ltd., New Delhi, 1967, 105.
11. Waksman SA, Fred EB. A tentative outline of the plate method for determining the number of microorganisms in soil. Soil. Sci., 1922; 14(1)**:**27-28.
12. Naphade KT, Raman S, Bijaj Singh BS, Patil DB. Management of organic material from agro industries for agricultural productivity. Bull. Indian Soc. Soil Sci., 1998; 19:154-164.
13. Alfred RS. Impact of paper and pulp factory effluent on soil, water and plant ecosystem. Ph.D.Thesis, Tamil Nadu Agric. Univ., Coimbator, 1998.
14. Hameed SM, Udayasoorian C. Changes in soil chemical properties and plant nutrients content under Eucalyptus irrigated with paper mill effluent and sludge in forest nurseries. In:Water world'98. National seminar on applications of treated effluent for irrigation, Regional Engineering College, Trichy, 1998, 38-49.
15. Juwarkar AS, Subrahmanyam PVR. Impact of pulp and paper mill wastewater on crop and soil. Water Sci. Technol. 1987; 19(5):693-700.
16. Sivasamy N. Phytoremediation potential of fodder crops in paper mill effluent polluted soil habitat. M.Sc.Thesis, Tamil Nadu Agric. Univ., Coimbatore, 2004.
17. Balusamy A, Udayasoorian C, Shanmugam TR, Jayabalakrishnan RM, Vinoth Kumar K. Environmental and Socio-Economic Impact of Treated Paper Mill Effluent Irrigation in Karur District of Tamil Nadu. Madras Agric. J. 2013; 100:336-342.
18. Almeida ICC, Fernandes RBA, Neves JCL, Ruiz HA, Lima TLB, Hoogmoed W *et al.* Soil Quality after Six Years of Paper Mill Industrial Wastewater Application. Rev Bras Cienc Solo., 2017, 41.
19. Udayasoorian C, Mini K, Ramaswami PP. Bagasse pith compost – An effective ameliorant in paper mill polluted soil environments. In: Proc. Bioremediation of polluted habitats, Tamil Nadu Agric. Univ., Coimbatore, 1999, 73-78.
20. Prabu PC. Bioremediation of paper mill effluent polluted habitat.Ph.D.Thesis, Tamil Nadu Agric. Univ., Coimbatore, 2003.
21. Chatterjee A, Joshi HC H. Pathak. Impact of distillery and paper mill effluent irrigation on yield of rice and soil fertility. J. Indian. Soc. Soil Sci., 2003; 51(4):564-566.
22. Hameed SM. Influence of paper mill (TNPL) solid wastes as amendments for forest nursery and their impact on soil properties. M.Sc. Thesis, Tamil Nadu Agric. Univ., Coimbatore, 1997.