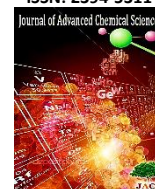




Contents List available at JACS Directory

Journal of Advanced Chemical Sciences

journal homepage: www.jacsdirectory.com/jacs

Evaluation of Physico-Chemical Variations of Marine Sediments in Ash Slurry Discharge Point of Tuticorin Thermal Power Plant in India

J. Clara Jeyageetha^{1,*}, Sugirtha P. Kumar²¹Department of Chemistry, A.P.C. Mahalaxmi College for Women, Tuticorin – 628 002, TN, India.²Department of Chemistry, Women's Christian College, Nagercoil – 629 001, TN, India.

ARTICLE DETAILS

Article history:

Received 17 June 2015

Accepted 27 June 2015

Available online 02 July 2015

Keywords:

Physico-Chemical Characteristics

Thermal Power Plant

Organic Carbon

Sediment Texture

ABSTRACT

The present study was carried out to determine the physico-chemical characteristics and the textural structure of sediments in Tuticorin coastal area for a period of six months during July 2014–December 2014 from 3 stations which were fixed in and around 5 km from ash slurry discharge point of Tuticorin thermal power plant. The pH values were increased with increase of distance from the ash slurry discharge point. The organic carbon of the stations varied from 4.236 to 7.85 %. Nitrogen content varied from 0.025 to 0.074 %. Calcium content ranged between 315.2 to 576.4 mg/g. Sediment texture ranged in terms of percentage of sand, silt, and clay were 36.9 to 90.35 %, 1.5 to 36.7 % and 15 to 35.3 % respectively at all stations. It was observed that organic carbon, nitrogen, and calcium in the sediments were high in station 1 due to ash slurry.

1. Introduction

Fly ash occurs as very fine spherical particles, having diameter in the range from few microns to 100 microns. Fly ash is ferro-aluminosilicate mineral with major elements like Si, Al and Fe together with significant amount of Ca, Mg, K, P and S [1]. The EPA has found that two factors dramatically increase the risk that coal ash disposal units pose, both to human health and to ecosystems: the use of wet surface impoundments rather than dry landfills, and the absence of composite liners to prevent leaking and leaching. Immediately after dumping the waste settled as a body over small areas of sea bed. Three historical surveys have previously been under taken of the receiving substrata and revealed that the physical nature of sediment environment had been principally altered by two properties of the waste: the fineness of the grains and the development of strong cohesiveness on contact with water (pozzolanic activity). The former has been suggested to contribute to the increased silt content of the sediments [2]. Sediment is also the major site for organic matter decomposition which is largely carried out by bacteria. Important macronutrients are continuously being interchanged between sediment and over-lying water [3]. Furthermore, sediments have an impact on ecological quality because of their quality, or their quantity, or both [4]. It is observed that continuous accumulation of pollutants due to biological and geochemical mechanisms, and cause toxic effect on sediment dwelling organisms and fish, resulting in decrease survival, reduced growth, or impaired reproduction and lowered species diversity [5,6]. The physicochemical character of sediments regulates the type of food, feeding and other life activities of benthic forms to a great extent [7]. In this study, we tried to determine the impacts of ash pollution on sediment. The pollution data of the present study is also expected to help in rational planning of pollution control strategies and their prioritization. The pH, organic carbon, calcium, nitrogen content and sediment texture of sediment were studied by taking sample from the polluted site and compared with results from unpolluted sediment samples.

2. Experimental Methods

2.1 Climatic Conditions

The city experiences tropical climatic conditions characterized with immensely hot summer, gentle winter and frequent rain showers. Summer extends between March and June when the climate is very humid. Tuticorin registers the maximum temperature of 39 °C (102 °F) and the minimum temperature of 32 °C (90 °F). The city receives adequate rainfall during the months of October and November. The city receives around 444 mm (17.5 inches) rainfall from the Northeast monsoon 117.7 mm (4.63 inches) during summer, 74.6 mm (2.94 inches) during winter and 63.1 mm (2.48 inches) during the south-west monsoon season. The coolest month is January and the hottest months are from May to June. The city has a very high humidity being in the coastal sector [8].

2.2 Area of Study and Sediment Sampling

The study area (Fig. 1) covered about 5 km from the slurry ash disposal point of thermal power plant. Station 1 (N 08° 46' 48.3" & E 078° 10' 76.3") is slurry ash discharge point, station 2 (N 08° 47' 32.0" & E 078° 10' 80.3") is 2 km away from the station 1 and station 3 (N 08° 47' 85.5" & E 078° 10' 65.3") is 3 km away from the station 2. The samples were taken using grab from the 3 stations for 6 months during the period of July 2014 to December 2014. The collected samples were quickly packed in air tight polythene bags and transported to the laboratory.

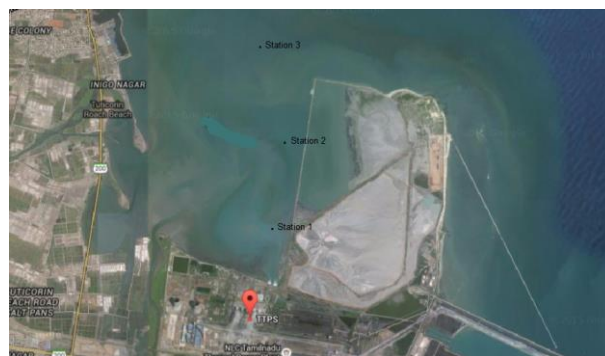


Fig. 1 Aerial view of Tuticorin Thermal Power Plant (TTPS)

*Corresponding Author:

Email Address: clarajeyageetha@gmail.com (J. Clara Jeyageetha)

2.3 Physico-Chemical Study

The present study provides a detailed description of the physico-chemical criteria of sediment samples. The samples were collected from the three stations by grab and transferred to polythene bags, then analyzed for pH, organic carbon, calcium, nitrogen, sediment texture. The standard techniques and methods were followed for physical and chemical analysis of sediment samples [9,10]. After sampling, samples were dried under shade and divided into two fractions. One portion for the analysis of sediments texture parameters (sand, silt, clay) and the other portion were powdered using mortar and pestle and sieved through 63 μ m sieve and analyzed for organic carbon. Precautions were taken to avoid contamination during drying, grinding, sieving and storage. Sediment pH was measured in a suspension of 1:2.5 sediment to water ratio using calibrated pH meter (Elico). Textural characteristics (sand, silt, clay) were determined following pipette analysis [11]. Organic carbon content in sediment was determined by wet oxidation method [12], nitrogen was estimated by Kjeldhal method as outlined by [13]. Calcium was estimated by extraction with ammonium acetate and titrated with EDTA [14].

3. Results and Discussion

The results of physico-chemical parameters of sediments are shown in Table 1.

Table 1 Mean and statistical characteristics of sediment between stations during July 2014 to December 2014

Parameters	Month	S1	S2	S3	Statistical Analysis			
					Mean	SD	CV	SE
pH	July	7.09	7.43	7.46	7.34	0.21	2.80	0.12
	Aug	7.50	7.54	7.64	7.56	0.07	0.95	0.04
	Sep	8.49	8.52	8.87	8.63	0.21	2.45	0.12
	Oct	7.82	7.49	7.64	7.65	0.17	2.16	0.10
	Nov	7.27	7.30	7.40	7.32	0.07	0.93	0.04
	Dec	7.98	7.21	7.63	7.60	0.39	5.07	0.22
Organic Carbon %	July	5.71	4.24	4.51	4.82	0.78	16.3	0.45
	Aug	5.36	4.44	4.53	4.77	0.51	10.7	0.29
	Sep	4.40	4.31	4.50	4.41	0.10	2.18	0.06
	Oct	5.40	4.92	4.80	5.04	0.32	6.35	0.18
	Nov	7.72	6.48	6.38	6.86	0.75	10.9	0.43
	Dec	7.85	6.26	6.03	6.71	0.99	14.8	0.57
Calcium mg/g	July	475	349	354	393	71.3	18.1	41.1
	Aug	555	495	500	517	33.3	6.44	19.2
	Sep	576	533	563	558	22.4	4.01	12.9
	Oct	500	497	478	492	12.3	2.50	7.08
	Nov	423	394	403	407	14.9	3.66	8.59
	Dec	335	315	330	327	10.4	3.20	6.03
Nitrogen %	July	0.031	0.057	0.027	0.038	0.016	42.29	0.009
	Aug	0.040	0.054	0.025	0.040	0.015	35.26	0.008
	Sep	0.043	0.040	0.039	0.041	0.002	4.919	0.001
	Oct	0.064	0.059	0.029	0.051	0.019	37.36	0.010
	Nov	0.074	0.060	0.064	0.066	0.007	10.92	0.004
	Dec	0.072	0.055	0.032	0.053	0.020	37.88	0.011

S1 = Station 1, S2 = Station 2, S3 = Station 3, SD = Standard Deviation, CV = Correlation Variation in %, SE = Standard Error

3.1 pH

The pH of sediments ranged from 7.2 to 8.87 (Fig. 2) during throughout the study period with the maximum values occurring in the month of September and minimum values occurring in the month of December [15]. Generally fluctuations in pH values during different seasons of the year are attributed to factors like removal of CO₂, dilution of sea water decomposition of organic matter. The pH of all the stations indicated the alkaline nature of the stations. Sediment physico-chemical properties results are presented in Table 1. The pH varied according to sites and seasons. Variations in pH might also be attributed to redox changes in sediments and water column apart from the influence of fresh water [16]. The lowest values were recorded at station 1. pH values were increased with increase of distance. The above 7.5 value of pH shows basic nature. The low value of pH recorded during monsoon month may be due to oxidation of FeSO₄ to H₂SO₄ [16]. Julie et al [17] and Selvin et al [18] were recorded low pH may be due to high temperature of fly ash dump area. So the sediments were showed the low pH in station 1 because of high temperature in the ash slurry discharge point.

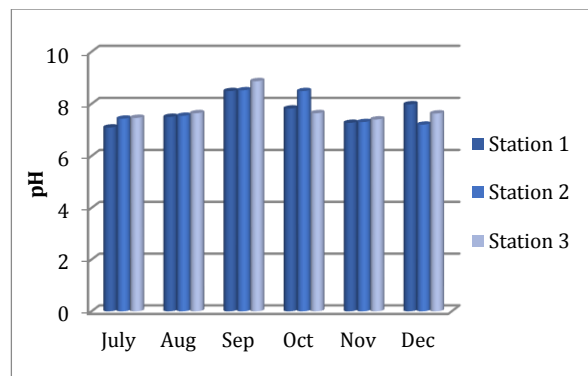


Fig. 2 Monthly variation of pH

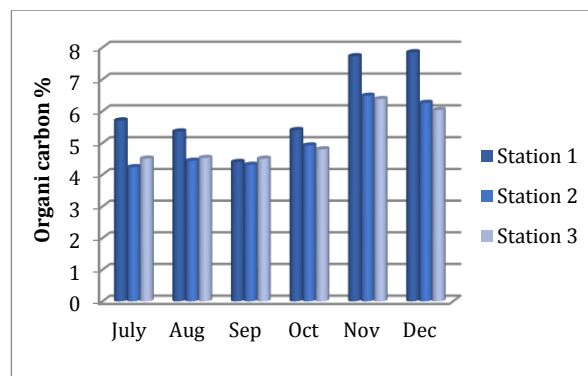


Fig. 3 Monthly variation of organic carbon

3.2 Organic Carbon

Organic carbon was varied from 4.236 to 7.85 % (Fig. 3). The lowest value was recorded in the month of July at station 2 which is located 2 km away from the ash slurry discharge point and highest values were recorded in the month of December at station 1 which is ash slurry discharge point. Yogesh Kumar et al [19] also recorded lowest value of organic carbon in the month of July in Gulf of Mannar coral Island. The distribution of organic carbon closely followed the distribution of sediment type i.e., sediment low in clay content was low in total organic carbon and as the clay content increased the organic carbon content also increased which as reported by Reddy and Hariharan [20]. Station 1 showed high clay content among the stations due to discharge of ash slurry so organic carbon was relatively high in station 1.

3.3 Calcium

Calcium level was varied from 315.2 to 576.4 mg/g (Fig. 4). The highest value was recorded in the month of September at station 1 and lowest value was recorded in the month of December at station 2. Maximum value was recorded in station 1 due to ash slurry. The increase of calcium found in this research contrasts with other studies where calcium was leached from coal ash sea water or exchanged by Mg [21-24]. It is known that coal ash has adsorption properties, which are magnified as the carbon content in the ash increases.

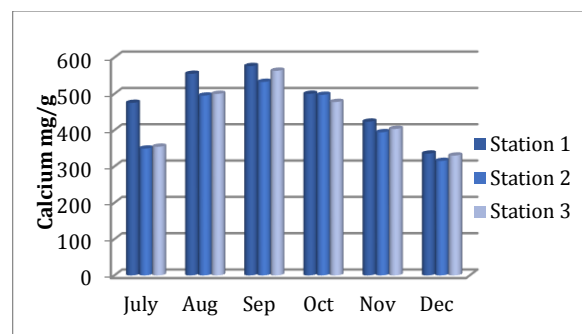


Fig. 4 Monthly variation of calcium

3.4 Nitrogen

Nitrogen in sediments varied from 0.025 to 0.074 % (Fig. 5). It was high in station 1 in the month of November and low in station 3 at July. Low level of nitrogen observed may be ascribed to the low level of organic matter with high percentage of sand in station 3. In the present study, total nitrogen in sediment was high during winter due to the oxidation of dead plant organic matter, which has settled on the top layer. The lower value of total nitrogen during monsoon season may be ascribed to low level of organic matter [25, 26]. Rani and Kalpana [27] also reported that application of fly ash to soil increased the nutrient availability such as nitrogen, phosphorus, and other micronutrients. The higher content of nitrogen has been observed in station 1 due to the direct discharge of ash slurry from the plant.

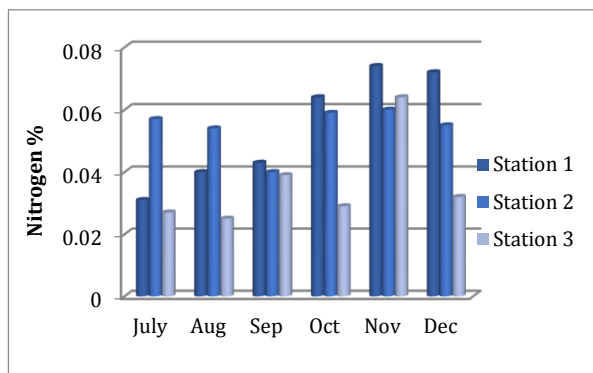


Fig. 5 Monthly variation of nitrogen

3.5 Sediment Texture

In Station 1 (Fig. 6), the sand fraction ranged from 36.9 % (September) to 54.5 % (July), in station 2 (Fig. 7) from 63.4 % (April) to 90.35 % (July), in station 3 ranged from 62.3 % (July) to 78 % (September). Silt fractions were observed in the study region which ranged from 7 % (July) to 36.7 % (September) in station 1, 1.3 % (July) to 11.3 % (November) in station 2, 1.4 % (July) to 13.3 % (November) station 3 (Fig. 7). Clay fraction was ranged from 17.5 % (December) to 38.5 % (July) in station 1, 17.1 % (September) to 35.3 % (July) in station 2, 15 % (September) to 36.3 % (July) in station 3. Sediment texture in terms of sand, clay and silt (%) were: 36.0-78, 15-38.5 and 1.3- 9.8 in all the 3 stations. Soil texture revealed dominance of clay and silt % in the station 1 with no much variation among them. Station 2 and 3 revealed dominance of sand. Alteration of the soil texture is possible through the addition of fly ash. Application of high rates of fly ash can change the surface texture of soils, usually by increasing the silt content was proved by the station 1 showed the highest silt content which is slurry ash discharge point.

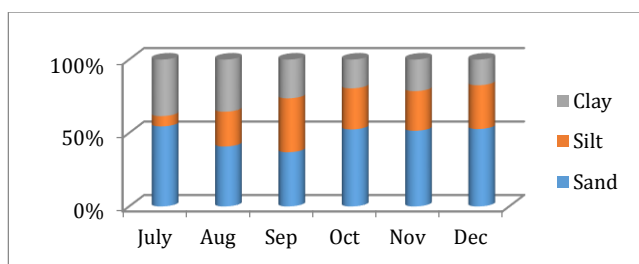


Fig. 6 Monthly variation of sediment texture in station 1

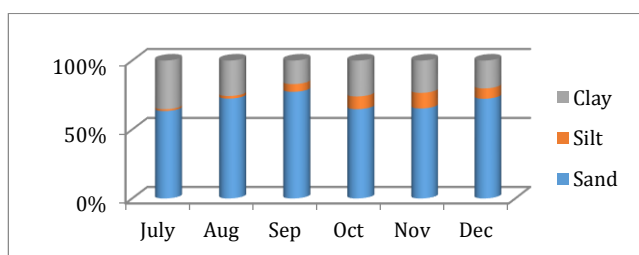


Fig. 7 Monthly variation of sediment texture in station 2

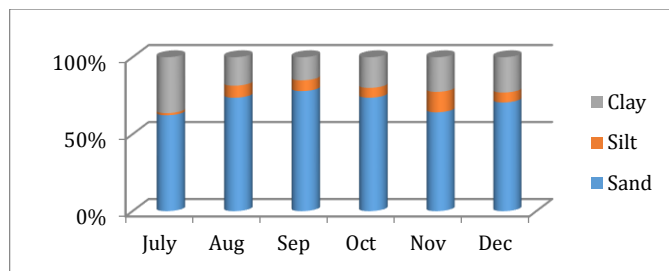


Fig. 8 Monthly variation of sediment texture in station 3

3.6 Correlation (r) Between Different Parameters

In the present study the correlation coefficient (r) between every parameter pairs in computed. Correlation coefficient (r) between any two parameters, x & y was calculated for parameter such as pH, organic carbon, calcium, nitrogen of sediment. The pH was found to show negative correlation with organic carbon in all the stations. There was strong positive correlation ($r = 0.7447$) between organic carbon and nitrogen in station 1 (Table 2), while in station 3 organic carbon and nitrogen was negatively correlated. In station 1 pH and calcium was weakly correlated, while rest of the stations (Table 3 and Table 4) were strongly correlated.

Table 2 Correlation matrix of station 1

Correlation	pH	Organic carbon	Calcium	Nitrogen
pH	1			
Organic carbon	-0.3482	1		
Calcium	0.2211	-0.9293	1	
Nitrogen	0.1234	0.7447	-0.6820	1

Table 3 Correlation matrix of station 2

Correlation	pH	Organic carbon	Calcium	Nitrogen
pH	1			
Organic carbon	-0.5767	1		
Calcium	0.7146	-0.5494	1	
Nitrogen	-0.9274	0.4608	-0.5110	1

Table 4 Correlation matrix of station 3

Correlation	pH	Organic carbon	Calcium	Nitrogen
pH	1			
Organic carbon	-0.4127	1		
Calcium	0.7213	-0.5639	1	
Nitrogen	0.0344	-0.7106	-0.0557	1

4. Conclusion

The physico-chemical characteristics of sediment varied according to season and also ash slurry discharge. Station 1 showed slight variation from other stations, but is normal range. The pH values showed the sediment was alkaline in nature; organic carbon and calcium were high in station 1. Station 1 showed the high silt content due to fly ash. Impacts of fly ash on sediment may be balanced by minimizing its accumulation either by utilizing or subjecting it to a stabilization process. As sedimentary organic carbon is the most important carrier for persistent organic pollutants, the spatial distribution pattern of organic carbon indicates that much attention should be paid to the sediments for environmental monitoring and risk assessment.

Acknowledgement

The authors are thankful to Suganthi Devadason Marine Research Institute (SDMRI), Tuticorin for providing lab facility.

References

- [1] W.R. Aswar, Fly ash disposal and utilization: National scenario, International Conference on Fly ash Disposal and Utilization, New Delhi, India, 2001, pp. 80–86.
- [2] R.N. Bamber, J.F. Spencer, The benthos of a coastal power station thermal discharge canal, *J. Marine Biol. Assoc. UK* 64 (1984) 603–623.
- [3] J.F.N. Abowei, F.D. Sikoki, Water pollution management and control, Double Trust Publications Company, Port Harcourt, 2005.
- [4] J. Stronkhorst, J. Brils, J. Batty, M. Coquery, M. Gardner, J. Mannio, et al, Discussion document on sediment monitoring guidance for the EU water framework directive, Version 2, EU water framework directive expert group on analysis and monitoring of priority substances, EUR, EN, 2004.
- [5] A.P. Mucha, M.T.S.D. Vasconcelos, A.A. Bordalo, Macrobenthic community in the Douuro Estuary: Relation with trace metals and natural sediment characteristics, *Environ. Pollut.* 121(2) (2003) 169–180.
- [6] S.M. Praveena, A. Ahmed, M. Radojevic, M.H. Abdullah, A.Z. Aris, Factor-cluster analysis and enrichment study of mangrove sediments-an example from mengkabong, Sabah, *Malaysian Jour. Anal. Sci.* 11(2) (2007) 421–430.
- [7] M. Radojevic, V.N. Bashkin, Practical environmental analysis, RSC, Cambridge, New York, 1999.
- [8] Kumar, Arvind, Environment and toxicology, APH Publishing Corporation, New Delhi, 2005.
- [9] APHA, AWWA and WEF, Standard methods for the examination of water and wastewater, 22nd edition, L.S. Clesceri, A.E. Greenberg, A.D. Eaton, (Eds.), American Public Health Association, American Water Work Association, Water Environment Federation, Washington DC, 2012.
- [10] M.L. Jackson, Soil chemical analysis, Prentice-Hall of India Private Limited, New Delhi, 1973.
- [11] W.C. Krumbein, F.J. Pettijohn, Manual of sedimentary petrology, Appleton, Century and Crofts, New York, 1938, pp. 549–555.
- [12] A. Walkley, I.A. Black, An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method, *Soil Sci.* 37 (1934) 29–37.
- [13] H. Barnes, Apparatus and methods of oceanography, Part I: Chemical, G. Allen and Unwin Limited, London, 1959, pp. 1–341.
- [14] L.A. Richards, Diagnosis and improvement of saline and alkali soils, USDA-SCS Agric., Handbook 60, US Govt. printing office, Washington, DC, 1954.
- [15] A. Saravanakumar, M. Rajkumar, J. Sesh Serebiah, G.A. Thivakaran, Seasonal variations in physico-chemical characteristics of water, sediment and soil texture in arid zone mangroves of Kachchh-Gujarat, *Jour. Environ. Biol.* 29 (2008) 725–732.
- [16] M. Holmer, E. Kristensen, G. Banta, K. Hansen, M.H. Jensen, N. Bussawarit, Biogeochemical cycling of sulphur and iron in sediments of a south-east Asian mangrove, Phuket Island, Thailand, *Bio. Geo. chem.* 26 (1994) 145–161.
- [17] M.R. Julie, M.W. Christa, J.C. Joseph Jr, J.H. Lara, Effects of global climate change on marine and estuarine fishes and fisheries, *Rev. Fish Biol. Fisher.* 14 (2004) 251–275.
- [18] S. Pitchaikani, G. Ananthan, M. Sudhakar, Studies on the effect of coolant water effluent of Tuticorin thermal power station on hydro biological characteristics of Tuticorin coastal waters, south east coast of India, *Curr. Res. Jour. Biol. Sci.* 2(2) (2010) 118–123.
- [19] J. S. Yogesh Kumar, S. Geetha, R. Sornaraj, Seasonal changes of sedimentation rates and sediment characteristics status in the gulf of mannar coral island, India, *Int. Lett. Natural Sci.* 1 (2014) 8–24.
- [20] H.R. Reddy, V. Venkataswamy, Hariharan, Distribution of nutrients in the sediments of the Netravathi-Gurupur estuary, Mangalore, *Ind. J. Fish.* 33 (1986) 123–126.
- [21] D.E. Hockly, H.A. Van Der Sloot, Long-term processes in a stabilized coal-waste block exposed to seawater, *Env. Sci. Tech.* 25 (1991) 1408–1414.
- [22] J.H. Parker, P.M.J. Woodhead, I.W. Duedall, H.R. Carlton Ocean disposal and construction with stabilized coal waste blocks, *Water Sci. Tech.* 15 (1983) 83–95.
- [23] A.L. Labotka, I.W. Duedall, P.J. Harder, N.J. Schlotter, Geochemical processes occurring in coal-waste blocks in the sea, in: I.W. Uedall, D.R. Kester, P.K. Park, B.H. Ketchum (Eds.), *Wastes in the Ocean, Vol. 4: Energy wastes in the ocean*, Wiley, New York, 1985, pp. 717–722.
- [24] O. Hjelmar, Leachate from land disposal of coal fly ash, *Waste Manag. Res.* 8 (1990) 429–449.
- [25] S. Bragadeeswaran, M. Rajasegar, M. Srinivasan, U. Kanaga Rajan, Sediment texture and nutrients of Arasalar estuary, Karaikkal, south-east coast of India, *Jour. Environ. Biol.* 28(2) (2007) 237–240.
- [26] G. Anitha, S.P. Kumar, Physicochemical characteristics of water and sediment in Thengapattanam estuary, southwest coastal zone, Tamilnadu, India, *Int. J. Env. Sci.* 4(3) (2013) 205–222.
- [27] K. Rani, S. Kalpana, Utilization in agricultural and related field; A better alternative for ecofriendly maintenance of coal fly ash, *J. Chem. Pharm. Res.* 2(5) (2010) 365–372.