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Study of utilization of ash pond effluents for plantation within thermal power plants

Deepthi G. V.[a], Mahesh Gupta[b] and Surjyoti Bagchi[b*]

[a]Manipal Institute of Technology, Manipal, India
[b]VIPL, Reliance Power, Butibori, Nagpur, India

ABSTRACT

In Coal-fired Thermal Power Plants, along with power generation, solid, liquidand gaseous effluents are generated day-to-day basis. Nowadays zero-discharge policy has been made mandatory for all the industries by the Pollution Control Board. Therefore effluents should be recycled and reused within the industry or it should be minimized rather than disposing the effluents out of the industry. This paper deals with the utilization of such liquid effluents especially ash pond effluent. Keeping this in view, a study was undertaken to analyse the quality of ash pond effluent and utilize it in the area of agriculture for irrigation of plantation crops. Important Water Quality Indices like Sodium Absorption Ratio (SAR), Residual Sodium Carbonate (RSC), Mg/Ca Ratio and physicochemical properties were evaluated. It is observed that the ash pond effluent was suitable for irrigation of plantation crops.

Keywords: Power plant, Effluent, Ash, Irrigation, Plantation.

INTRODUCTION

Coal fired power plants use coal, air and water inputs to generate electric power. In thermal power plants large amount of water is used for generation of steam, cooling and disposal of ash to ash settling ponds. During this process solid, liquid and gaseous effluents are generated. Liquid effluents generated within power plants can be classified in three categories as, high-turbidity effluents, high-dissolved-solid effluents including acidic/alkaline effluents and oily effluents. Oily effluents are collected separately and treated in Effluent Treatment Plant. Liquid effluent is mainly composed of waste water from cooling tower and service water from different source which is reused for dust suppression and boiler blow down quenching. These power stations generate about 2700 MT/day of ash, part of which is disposed off to ash ponds as ash slurry and rest is used in cement industry and brick manufacturing . Ash disposed off in ash pond settles down slowly from slurry and deposits at the bottom of the pond whereas clear water stays on the top of it. This water is then collected and stored in weirs . Then the water is pumped to tube settler where it undergoes a coagulant-based chemical treatment to remove turbidity and suspended solids.Then the water is reused for ash slurry preparation. To find out the efficient way of using this water other than conveying ash , a study was done to characterize the ash water and their utilization potential particularly for plantation purposes.

EXPERIMENTAL SECTION

Sample analysis:
Samples of ash pond effluents were collected from the outlet of tube settler every day for one year and the sample is categorised as Pre monsoon (April –June) ,Monsoon(July- September) and Post monsoon (October to March) . pH and Electrical Conductivity (EC) of the samples were analyzed using Mettler Toledo FE20-Iand SpectroSLE-263C respectively. Total cations and anions present were calculated by following standard procedures [1].

Characteristics of sample:
After analysis of water samples for different parameters like total salt (EC) and cations and anions, it is imperative to calculate certain indices in order to access the water quality and its subsequent effect on soils. Important indices of water quality used with their significance are given below [1]. As per Indian Standards IS: 11624-1986 [2]total salt concentration is expressed as the Electrical Conductivity (EC). If the water is used for irrigation, one has to check its salinity because salinity in agricultural terms is the excess of salts above the level plant require. Most often it poses constrainsin the growth hence productivity of the crops reduce, thereforeis a serious concern. Salinity occurs through natural or human induced processesthat result in the accumulation of dissolved salts in the soil water toan extent that inhibits plant growth. Sodicity is a secondary result ofsalinity in clay soils [3].Salts in the soil water may inhibit plant growth for tworeasons:(i) The presence of salt in the soil solution reduces the ability of the plant to take up water and this leads to reduction in growthrate. (ii) If excessive amount of salt enters the plant, there will be injury to cells in the transpiring leaves andthis may cause further reductions in growth [4].

1. Sodium Absorption Ratio (SAR): It is calculated to indicate sodicity or alkalinity hazard of irrigation water. It expresses the relative activity of sodium ions in the exchange reactions withthe soil. This ration measures the relative concentration of sodium to calcium and Magnesium.

$$\text{S.A.R.} = \frac{Na^{+}}{\sqrt{\frac{1}{2}(Ca^{2+} + Mg^{2+})}}$$

where concentration of cations is in meq/l.

2. Residual Sodium Carbonate (RSC): This index is important for carbonates and bicarbonates rich irrigation water.

$$RSC = (CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+})$$

Both concentration of cations or anions is in meq/l.

3. Mg/Ca ratio: Higher levels of magnesium usually promote higher development of exchangeable sodium in irrigated soils.

RESULTS AND DISCUSSION

The physicochemical properties of ash pond effluent of pre monsoon, monsoon and post monsoon are presented in Table 1. The Water Quality Indices, Indian Standard Guidelines for the Quality of Irrigation Water IS: 11624-1986 is mentioned in Table 2. Guidelines of Clemson University agriculture service laboratory USA for interpretation of Water Quality for Irrigation is given in Table 4 [5]. List of crops that were already tested with irrigating it with ash water are mentioned in Table 5. The plants showed desirable yield and the plants were not harmed in anyway. Results of the samples taken are presented in Table 3. In relation to the hazardous effect of the total salt concentration, the irrigation water can be classified into four major categories as shown in Table 2.

Significance of Sodium Absorption Ratio (SAR):Highsodium ions in water affect the permeability of soil and causes infiltration problems. This is because sodium when present in the soil in exchangeable form replaces calcium and magnesium adsorbed on the soil clays and causes dispersion of soil particles. This dispersion results in breakdown of soil aggregates. The soil becomes hard and compact when dry and reduces infiltration rates of water and air into the soil affecting its structure.

Table 1: Physicochemical properties of Ash Pond Effluent

S.No	Parameter	Unit	Pre Monsoon April-June	Monsoon July-Sept	Post Monsoon Oct-March
1	Acidity-Alkalinity	pH	8.5	7.8	8.2
2	Electrical Conductivity	dSm^{-1}	1.7	0.8	1.4
3	Total Dissolved Solids	mg/l	1020	480	840
4	Total Suspended Solids	mg/l	30	10	20
5	Calcium	meq/l	6.4	4.6	4.5
6	Magnesium	meq/l	5	2.6	1.9
7	Sodium	meq/l	4	1.3	3
8	Chloride	meq/l	4.6	3.2	3.2
9	Bicarbonate	meq/l	2.56	1.96	3
10	Carbonate	meq/l	0.72	-	-
11	Sulphate	meq/l	10	8	12
12	Phosphate	meq/l	2	2	2
13	Oil and Grease	mg/l	BDL	BDL	BDL

Table 2: Water Quality Indices and Indian Standards for Irrigation Water

S.No	Characteristics	Water Quality Indices	Indian Standard IS : 11624 - 1986
1	Sodium Absorption Ratio (SAR) in meq/l	Safe < 10	Low SAR < 10
		Moderately safe 10 – 18	Medium 10 - 18
		Unsafe > 26	High> 26
2	Residual Sodium Carbonate (RSC) in meq/l	Safe < 1.25	Low < 1.5
		Moderately safe 1.25 – 2.5	Medium 1.5 – 3.0
		Unsafe > 2.5	High > 6.0
3	Magnesium/Calcium Ratio (Mg/Ca)	Safe Mg/Ca<1.5	-
		Moderately safe Mg/Ca 1.5 – 3.0	-
		Unsafe Mg/Ca> 3.0	-
4	Salt Concentration EC (mmhos/cm)	-	Low < 1300
			Medium 1500 - 3000
			High > 6000
5	pH	-	-
6	Suspended Solids (mg/l)	-	-
7	BOD (mg/l)	-	-

Table 3:SAR, RSC and Mg/Ca Ratio for the Ash Pond Effluents

S.No	Characteristics	Pre Monsoon	Monsoon	Post Monsoon
1	SAR	1.67	0.685	1.67
2	RSC	-8.12	-5.24	-3.4
3	Mg/Ca	0.78	0.57	0.42

**RSC values can be considered as zero [6].*

Table 4: Guidelines for interpretation of Water Quality for Irrigation

S.No	Irrigation	Degree of Problem		
	Salinity	No Problem	Increasing Problem	Severe Problem
1	EC (mmhos/cm)	0.5 – 0.75	0.75 – 3.0	> 3.0
2	TDS (ppm)	< 500	500 – 2000	> 2000
	Specific Ion Toxicity			
1	Chloride (ppm)	<70	70 - 300	>300
2	Boron (ppm)	<1.0	1.0 – 2.0	> 2.0
	Miscellaneous Effects			
1	NO_3-N (ppm)	< 50	50 – 100	>100
2	HCO_3 (meq/l)	< 1.5	1.5 – 8.5	> 8.5
3	pH	6.5 – 8.0	-	< 6.0 or > 8.0

Significance of Residual Sodium Carbonate (RSC: A large amount of bicarbonate tends to precipitate out the calcium, as calcium carbonate from soil and water. Magnesium enters the exchange complex of the soil replacing the precipitated calcium. Usually magnesium does not replace calcium to any great extent but, if calcium is precipitated as it is released, the reaction proceeds to completion. As calcium and magnesium are lost from the soil

water, a relative proportion of sodium is increased, which again becomes a problem. So both SAR and RSC values should be as low as possible.

Table 5: Plants irrigated with ash water

S.No	Name of the crops		Salinity tolerance
	Scientific name	Common name	
1	Plumeria alba	White frangipani	Moderate
2	Peltophorumpterocarpum	Yellow Poinciana	High
3	Pongamiapinnata	Poongam Oil Tree	High
4	Casuarina*sp*	Ironwood	Moderate
5	Phyllanthusemblica	Amla	High

** Moderately saline:Can withstand up to EC = 2–6 dSm^{-1}.*
Highly saline:Can withstand up to EC = 6–15 dSm^{-1}.
Source: FAO land and plant nutrition management service, 2008 [7].

Significance of Mg/Ca ratio:Soils containing high levels of exchangeable magnesium are often thought to be troubled with soil infiltration problems. At present there is reasonably good agreement that magnesium acts on soils in a way which is more like calcium than sodium, and that it is preferentially adsorbed by the soil to a much greater degree than sodium but to a slightly less degree than calcium.In magnesium dominated water (ratio ofCa/Mg < 1) or a magnesium soil, the potential effect of sodium may be slightly increased. In other words, a given SAR value will show slightly more damage if the Ca/Mg ratio is less than 1. The lower the ratio, the more damaging is the SAR.

In this study it is observed that total salt concentration value is in low to medium category i.e. 800 to 1700 micromhos/cm (mmhos/cm) or 0.8 to 1.7 dSm^{-1}. SAR, RSC and magnesium to calcium ratio (Mg/Ca) values were found to be in safe limits proving that ash water is suitable for irrigation.

CONCLUSION

The results of Table 4 show that water quality of ash pond is in “NO PROBLM” category as per the guidelines, if the water is used for plantation purposes. Therefore, it is concluded that Ash pond Effluent quality of Thermal Power Plant is suitable for plantation purposes. So by using ash effluents for plantations purposes, freshwater usage for plantations is reduced and wastewater is also minimized. Thus, this method serves dual purposes and it is also effectively proven.

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