International Conference "Water, Environment, Energy and Society" (WEES–2009)
New Delhi, 12–16 January 2009

EIA Study of Ash Pond of a Thermal Power Plant in Jharsuguda District, Orissa, India

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ABSTRACT: A super Thermal Power Plant is likely to come up in Jharsuguda district by the Orissa Government and an Industry under Public-Private partnership. The ash generated in the thermal Power plant will be stacked in Ash ponds in the areas earmarked for the Industry. Environmental Impact Assessment of Ash Ponds on the groundwater regime in the watershed covering the proposed plant area and Ash Pond area has been made through establishing 32 observation wells for periodical monitoring of groundwater level and groundwater quality. Bedhan river flows along one boundary of the watershed. Aquifer geometry has been determined by carrying out 50 multi-electrode resistivity imaging surveys covering ash ponds and Super Thermal Station Complex. Aquifer characteristics were estimated by carrying out pumping tests at five locations and also infiltration rates were determined through infiltration tests. The area exposes a wide spectrum of rock types. Groundwater occurs in the porous sedimentary formations and fractured igneous and metamorphic rocks in unconfined to confined conditions. The groundwater prospects indicate that the Pedi-plane shallow weathered and Lateritic plane shallow formations in the area are having a poor permeability supported by steep gradients of groundwater levels. Significantly, none of the major lineaments are found traversing the Ash pond. The Valley fill shallow formation is not extending beyond the stream on west. Hydrogeological evidence suggests that there seems to be no possibility of contaminant migration passing through the lineaments. Groundwater flow and mass transport processes models have been developed using the integrated database and predicted the likely migration of contaminants in groundwater from the ash ponds. The hydrogeological, geophysical, remote sensing, water level and water quality-monitoring database, *prima facie*, does not predict contamination of groundwater from the Ash Pond of the captive Power Plant. The lateral migration of TDS plume for 50 years will be in the downstream side along the stream course, which is however, falling within the boundary of assigned Ash Pond Area of the industry. As a remediation measure, it is suggested to reduce pressure of Leachate within the Ash Pond by Pumping leachate from the bottom of Ash Pond and spraying it through sprinklers to keep ash under wet condition in the Ash Pond.

INTRODUCTION

A joint sector Super Thermal Power Plant has been proposed by Sterlite Energy Pvt Limited in Jharsuguda District, Orissa. The water requirement for the power plant will be met from nearby Hirakund Reservoir. The Power plant is coming up around Brundamal village. Solid waste disposal from power plants will be in the Ash pond, which may likely to contaminate the ground-water regime in the area. The study aims at assessment of groundwater conditions and predicts future scenarios of groundwater contamination if any from the associated Ash Ponds of Super Thermal Power Plant.

Periodical monitoring of groundwater level and groundwater quality in the watershed covering green field expansion project area has been carried out by establishing 32 observation wells. Surface water samples were collected at 4 locations in Bedhan River and streams. Aquifer geometry has been determined by carrying out multi-electrode resistivity imaging at 50 locations in the watershed covering ash ponds and Aluminum Smelter Complex. Aquifer characteristics were estimated by carrying out pumping tests at five locations and infiltration tests were also carried out at the same locations. The groundwater prospects maps prepared by NRSA under Rajiv Gandhi Drinking Water Mission has been analyzed for ascertaining occurrence of lineaments in the area and their orientation (Figure 1).

The area exposes a wide spectrum of rock types. The Peninsular Gneiss comprising augen gneiss and migmatite represent oldest rocks of Archaean to Lower Proterozoic age. Soil, alluvium and laterite are younger formations in the area. Laterite occurs in small, isolated, irregular outcrops, spread over the area. Unclassified soil/alluvium of the Quaternaries occupies

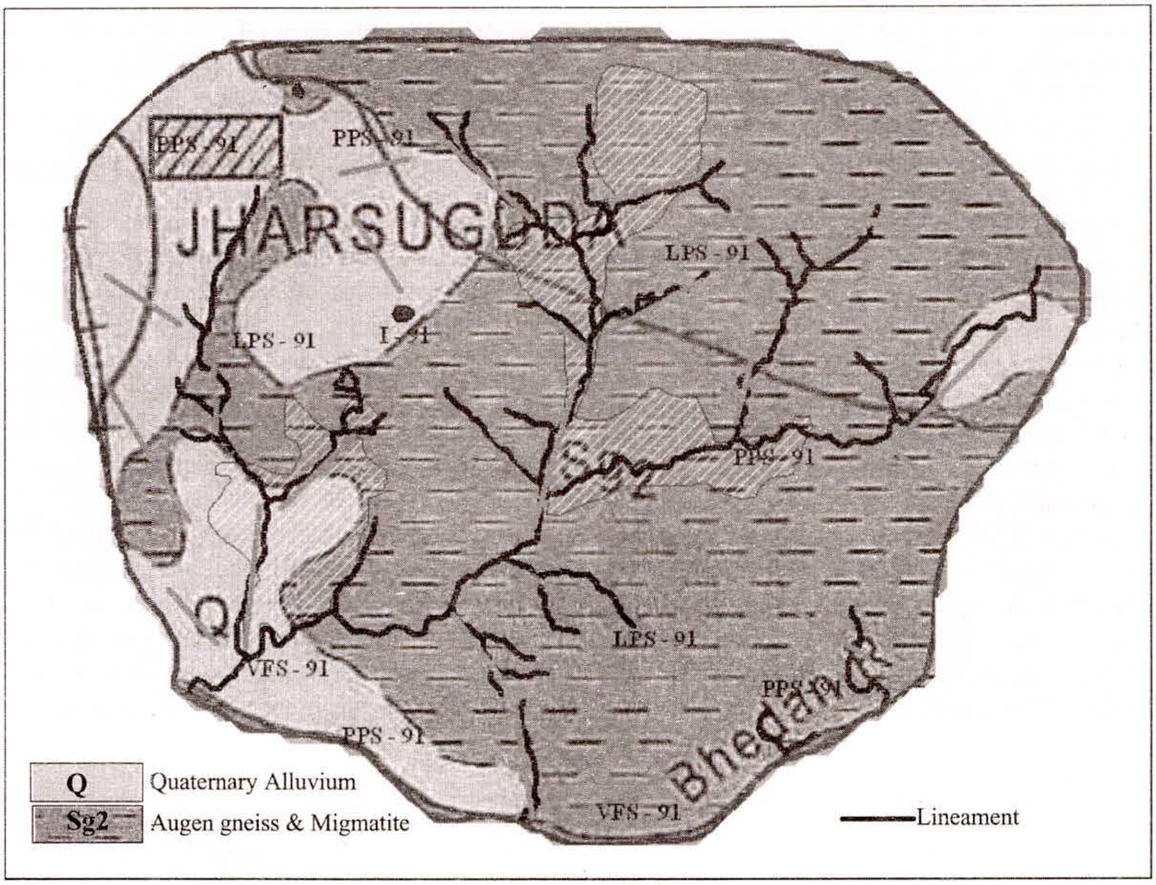

Fig. 1: Geology and Groundwater Prospects map showing Lineaments in the watershed

large area in the Mahanadi river valley and over the gneissic country, east of Jharsuguda. The area receives about an average annual rainfall of 1232 mm/year.

Groundwater occurs in the porous sedimentary formations and fractured igneous and metamorphic rocks in unconfined to confined conditions. The weathered and fractured zones of crystalline rocks constitute predominant hydrogeological units. Groundwater occurs under phreatic conditions in the weathered horizons. Highly weathered and jointed granitic gneisses occurring in the undulating plains form potential aquifers in the hard rock terrain. Depth to water level varies from 3–8.5 m (bgl) during pre monsoon period and 1.4–8.5 m during post monsoon period. Seasonal water level fluctuation is of the order of 2–4 m.

Spatial distribution of groundwater occurrence, configuration of water table and yield characteristics show that groundwater is restricted to weathered residuum, low to moderate yield 2–10 lps with high yielding pockets (15 lps) along Ib river. Most of the study area is occupied by moderately thick, discontinuous confined to unconfined aquifer with yield <15 LPs. Some part in the north groundwater is restricted to weathered residuum and fracture zones having secondary porosity, yield < 10 lps. The groundwater level contours show a predominant flow towards Bhedan river and local flow towards the stream courses. Little base flow has been observed in the stream near Tarkimal indicate the nature of groundwater effluence even during March. Enquiries with locals confirm that even during summer months streams in the area maintain meager base flows and Bhedan river sustains flows with at least 20–30 cm water column.

GROUNDWATER CONDITIONS

An inventory of 50 wells, including mostly dug wells and hand pumps, has been made and 32 observation wells have been selected for periodical monitoring of water level and water quality in the area. Dug well sections indicate, at places, the exposure of weathered granite gneissic rocks. The maximum depth in dug wells was found to be about 9 m near Kumaradhi. The exposed dug well section clearly shows poorly fractured gneissic aquifer. Lined dug wells show the presence of weathered gneissic aquifer in the Bhurkhamunda village near the Smelter Complex. In general, lined dug wells suggest that groundwater occurs in the weathered rocks only. The weathering of gneissic rocks varies from 5–8 m. Minimum depth to water level (2.85 m bgl) has been noticed in the Brundamal village (J15) close to a lineament. The maximum depth to water level has been noticed in Kumaradhi (J9) West of the Ash Pond. All observation wells have been connected to reduced mean sea level and the groundwater level contour map of March 2006 has been prepared. Groundwater level contours indicate steep gradients around the Ash pond area, which could be due to poor permeability of granitic gneissic rocks, and general flow direction is towards the Bhedan River. General groundwater flow direction is towards the Bhedan river. The influence of lineaments controlling groundwater movement could be seen in the groundwater level contours around Kurebaga. Groundwater hydraulic gradient on both sides of the stream adjacent to Ash pond indicates that the stream receives groundwater effluence as base flows. The flat gradient between the Kurebaga and Bhedan river may be due to valley fill deposits possessing slightly higher permeability. The hydraulic gradient of groundwater contours does not support possibility of contaminant migration towards Kurebaga village.

MULTI-ELECTRODE RESISTIVITY IMAGING

Electrical imaging of the sub-surface has been carried out using a 48 channel Multi-electrode resistivity imaging system at 50 locations well spread over the watershed (Figure 3). Wenner-Schlumberger configuration of electrode spacing has been deployed for getting maximum depth of investigation up to 45 m. There are 8 soundings in the Ash Pond for determining the aquifer geometry. The imaging technique initially draws measured apparent resistivity pseudo-section followed by drawing of calculated apparent resistivity pseudo-section. Forward modeling program RES2DINV computes the Inverse model Resistivity section. The Inverse Model resistivity section of the sub-surface within Ash ponds (Borhamunda—Kumaradih) indicate occurrence of weathered granite and granite gneiss

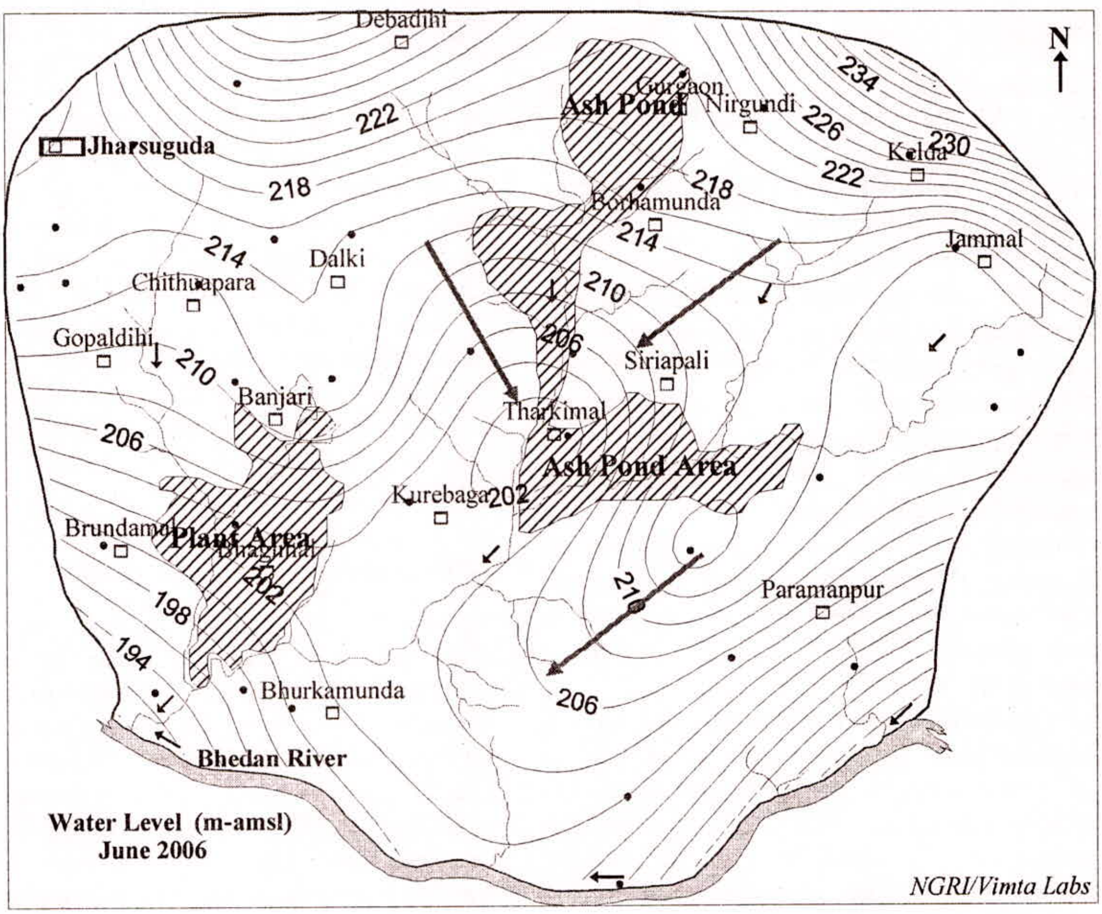

Fig. 2: Groundwater Level contours in m (amsl)—Pre monsoon June 2006

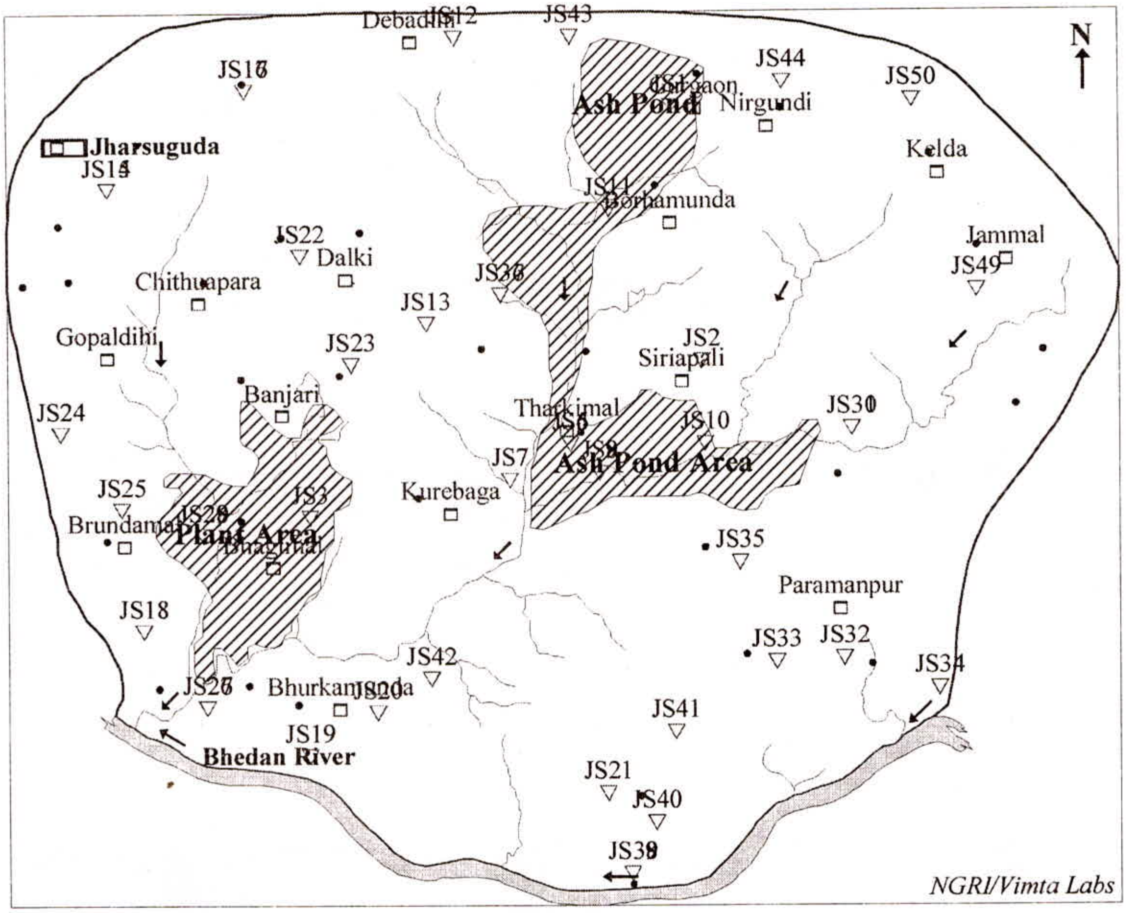

Fig. 3: Location of Multi-Electrode Resistivity Imaging in the watershed

with <100 ohm-m at shallow depth up to 20–22 m and the compact basement of granitic gneissic rock could be seen at a depth of 30 m (>300 ohm-m).

In general interpreted resistivity sections indicate a thin top soil and weathered rock followed by a fracture zone, which is underlain by a hard massive granitic gneissic basement rocks (Figure 4). Sounding data of JS7, JS8 and JS10 indicate higher apparent resistivity at depths >20 m in the downstream of Ash pond indicating shallow basement in the Laterite pediplane shallow formation. Around the Smelter complex (JS19, JS20 and JS 21) indicate lower apparent resistivity values due to presence of valley fill deposits and depth to the basement rocks is around 20 m only around Bhedan river. The thickness of weathered zone increases west of the Ash pond representing Kumarapalli (Kumaradih)—Brundamal (Figure 5). Lower apparent resistivity values indicate the influence of lineament particularly around Brundamal. Combined thickness of weathered and fractured zone is <15 m with a shallow basement between Paramanpur and Bhedan river.

GROUNDWATER QUALITY

The water quality for major ions was assessed for 32 groundwater samples collected during January 2006. The pH of groundwater is ranging from 7.3–8.5 whereas the surface water has pH value of 8.0. TDS concentration of groundwater is varying from 76–543 mg/l with chloride and sulphates less than 163 mg/l and 41 mg/l respectively. Fluoride concentrations in groundwater are found to be < 0.7 mg/l. In general the groundwater quality is potable.

Pumping tests have been carried out on dug wells at 5 locations covering the Ash pond and Smelter complex (Figure 6). Pumping was carried out for 3–4 hours and recovery in the wells was observed for next two days. The estimated Transmissivity around Kumradhi is 36m^2/day whereas Borhamunda has reported transmissivity of 55 m^2/day. All the values were estimated considering saturated zone thickness of 4–5 m of weathered rocks under phreatic conditions. The reported drawdown in the large diameter (4 m) dug wells for 3 hours pumping was ranging from 3–4.6 m.

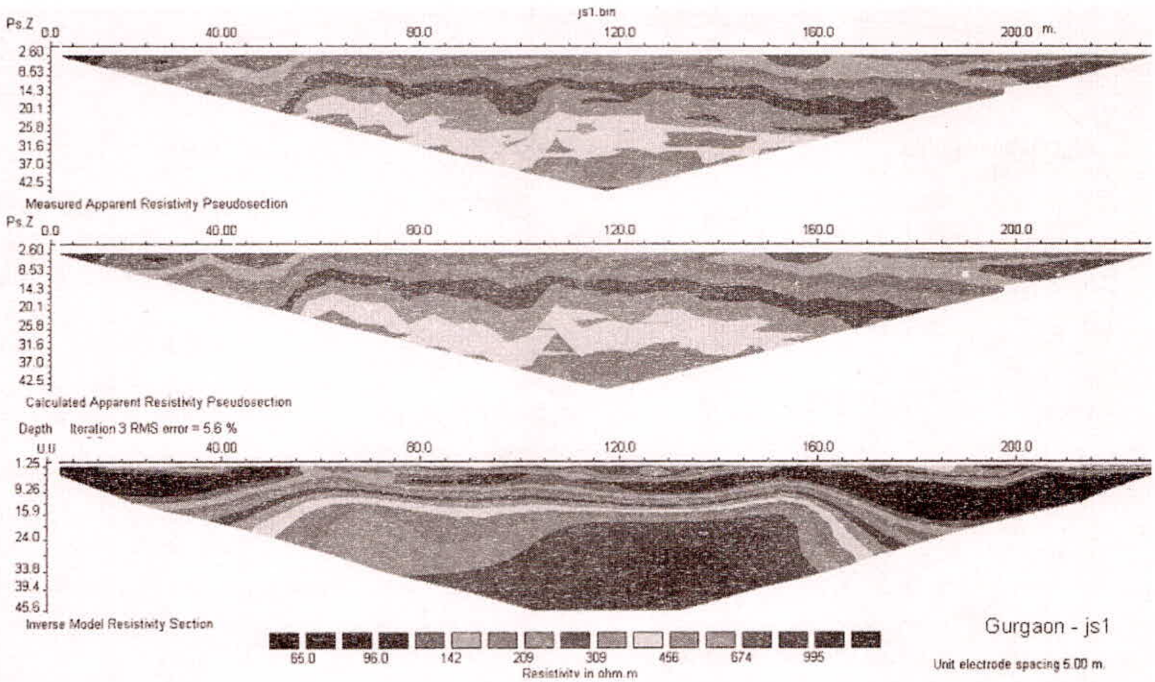

Fig. 4: Measured & Calculated Apparent Resistivity Pseudo sections & Inverse Model Resistivity Section from Multi Electrode Resistivity Imaging

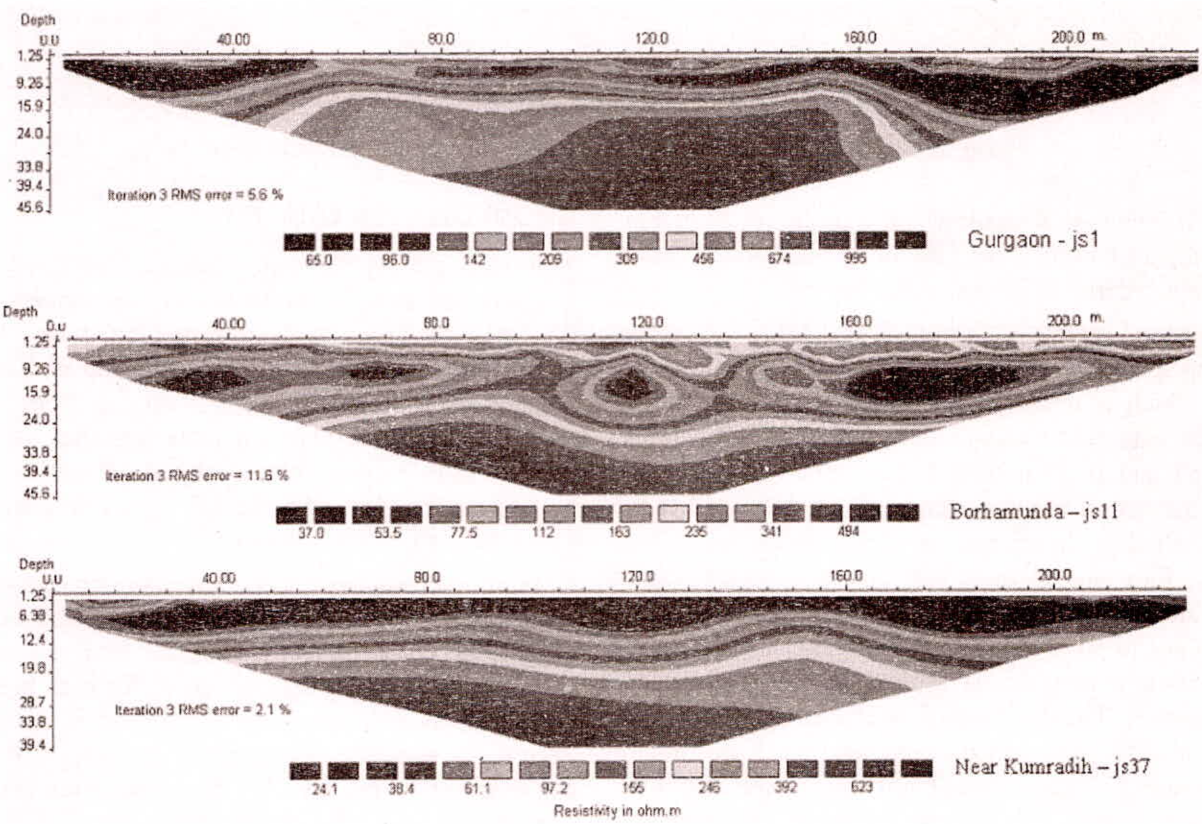

Fig. 5: Inverse Model Resistivity Sections from Multi Electrode Resistivity Imaging in the Ash Pond Area

Watershed covering Ash Pond & Power Plant Areas, Sterlite Energy Private Limited, Jharsuguda, Orissa

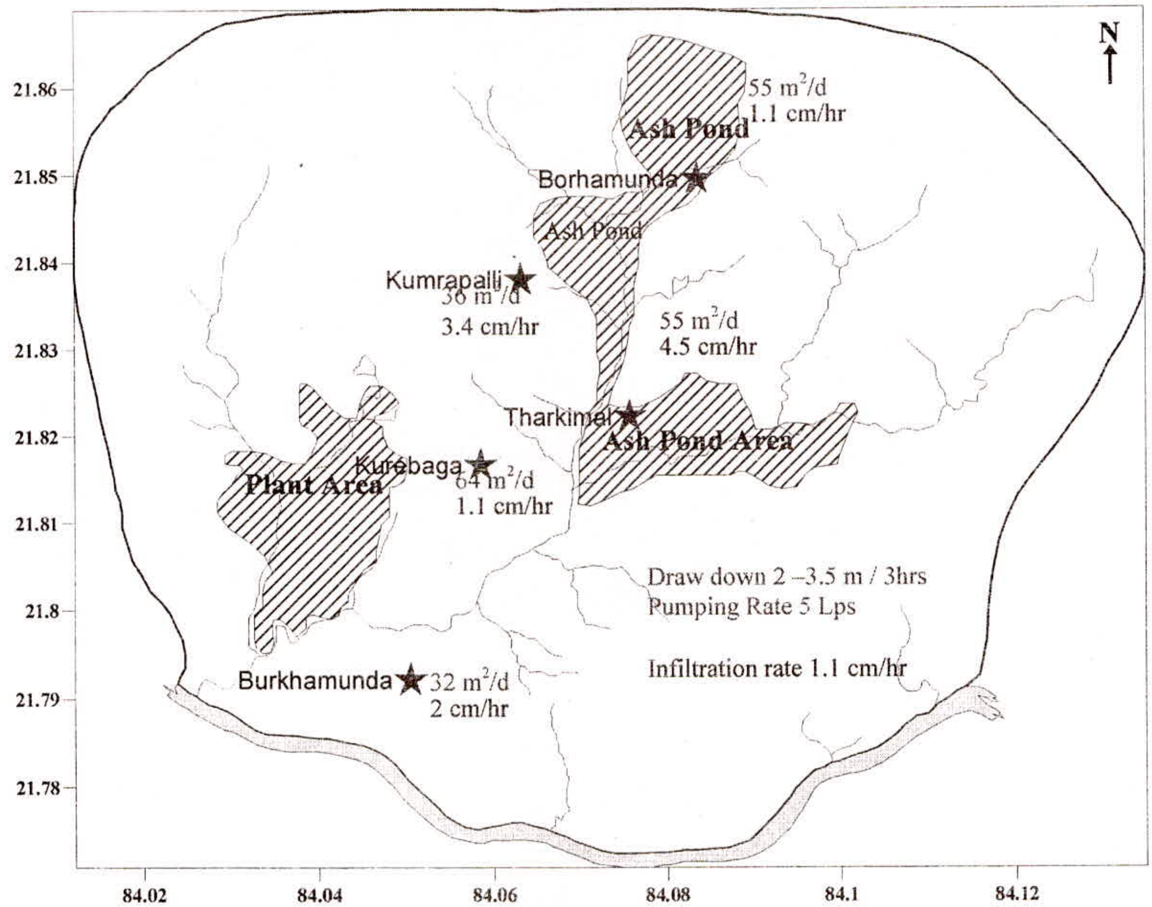

Fig. 6: Location of Pumping Tests & Infiltration Tests in the watershed

The infiltration rate observed is found varying from 1.1–4.5 cm/hr. The infiltration rate reported at Borhamunda near the Ash Pond was the lowest 1.1 cm/hr found in the area.

Groundwater flow and mass transport processes have been conceptualized considering the Ash Pond area in the centre of the allocated area between Kumradhi and Siriapally. A two-layer aquifer system covering weathered and fractured zones with a total thickness of 25–35 m. The permeability values assigned in the model varied from 4–6 m/day and a permeability value of 4.8 m/day was simulated within the Ash Pond area. Variable effective groundwater recharge rate of 35 mm/yr close to Bhedan river and 40 mm/year around the Ash Pond area has been assigned considering the moderate recharge condition over the Pediplane shallow weathered and Lateritic Plane shallow formations. Most of the rainfall may leave the watershed as base flow to the streams and thus effective recharge will be very low. Effective groundwater recharge of 45 mm/yr has been assumed in the Ash Pond. Pumping centers of water supply wells and irrigation wells has been enumerated and incorporated appropriately in the model. The groundwater head distribution was computed using Visual MODFLOW simulation code and the groundwater flow has been calibrated for March 2006 water level condition. The computed groundwater velocity field represents a groundwater velocity of 15 m/yr around the Ash ponds.

Using the computed velocity field, mass transport simulation was carried out using MT3D software by assigning TDS concentrations varying from 1500 mg/l during first 20 years, with 2000 mg/l during later 20 year period and with 1800 mg/l during last 10 year period at Ash Pond. Stacking of Ash will be done in phases starting from the Ridge area within the life span of 50 years. The Ash Pond leachate was assumed to be reaching the groundwater table with the above concentrations during the respective periods. The initial average TDS concentration was assumed to be 400 mg/l. The computed TDS plumes originating from

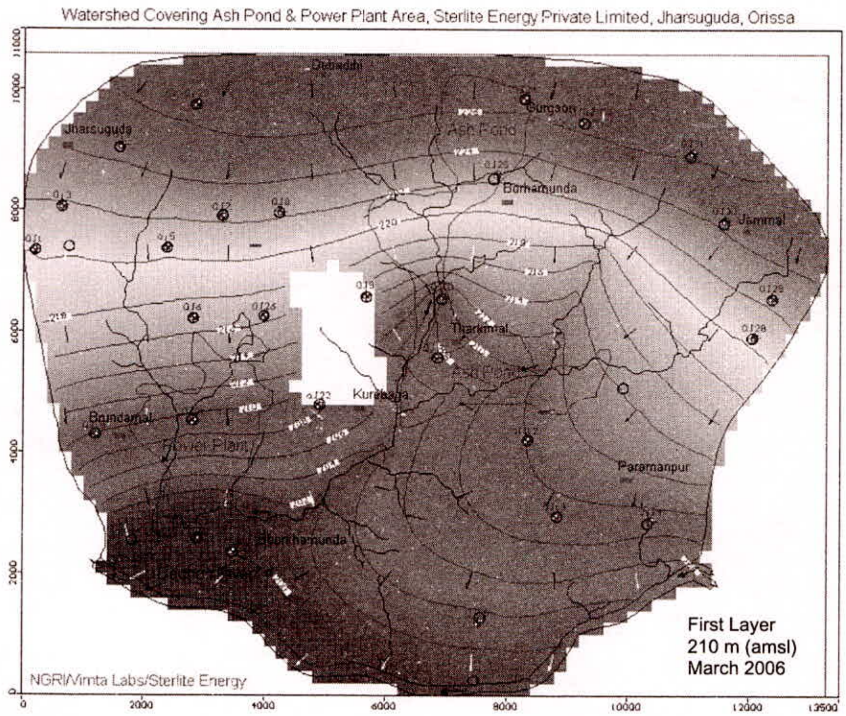

Fig. 7: Computed Groundwater Level in m (amsl)—Groundwater Flow Model

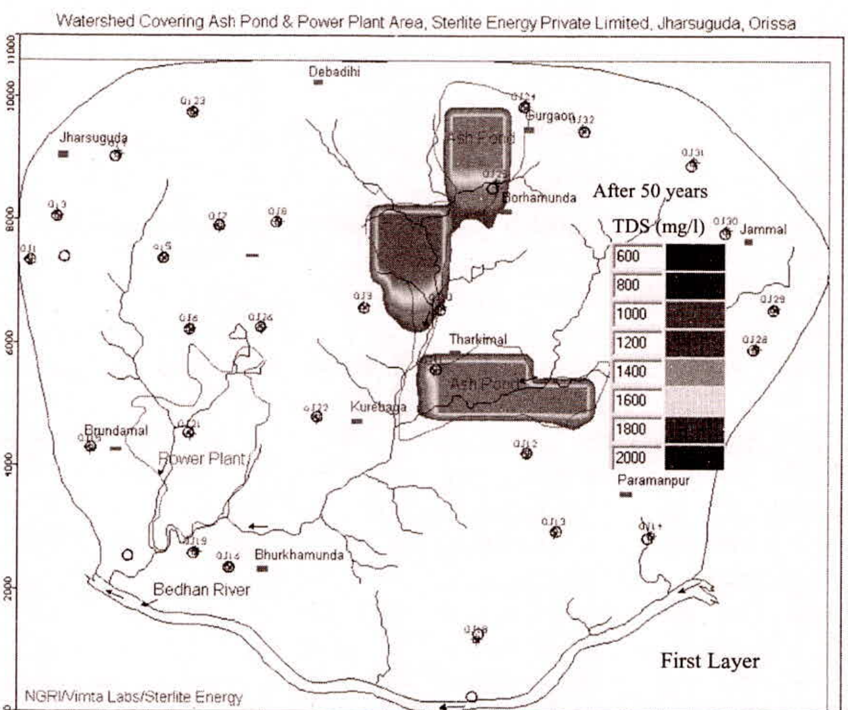

Fig. 8: Contaminant Migration from proposed Ash Ponds of Super Thermal Power Station near Jharsuguda, Orissa after 50 years

the Ash Ponds are found to be contained within the earmarked area of Sterlite Energy Ltd as the preferred groundwater flow direction is towards the Bhedan river. The contaminant migration will be spreading in the downstream side up to a distance of about 1 km during next 50 year period within the assigned Ash Pond area only (Figure 8). It will not reach the Bhedan river. As regards the migration of TDS plume in the second layer, representing fractured zone may attain concentration of <1000 mg/l after 50 years (Figure 9).

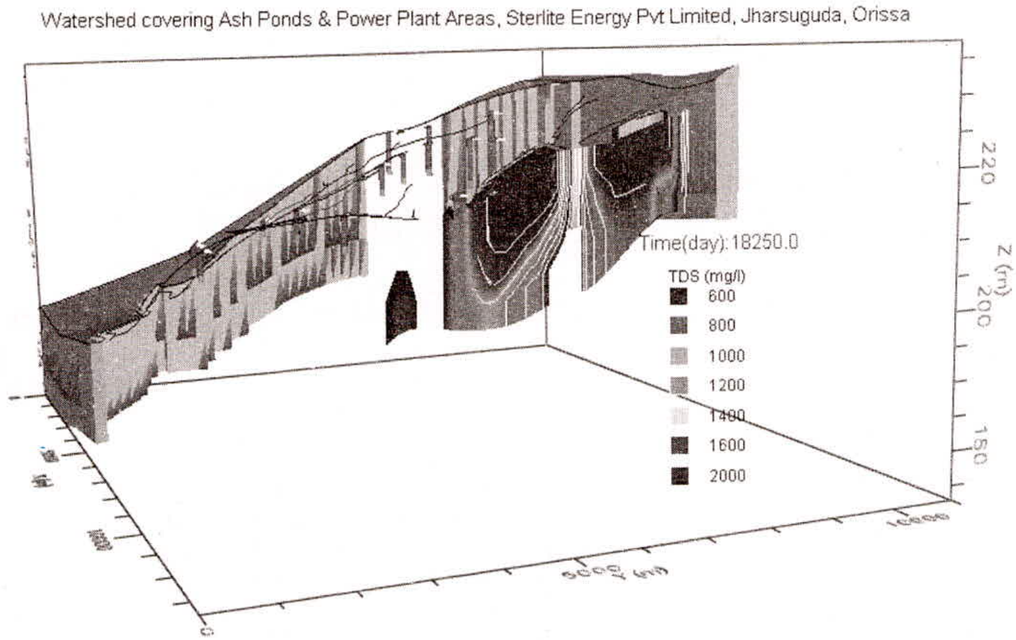

Fig. 9: Contaminant Migration along Vertical Direction from proposed Ash Ponds of Super Thermal Power Station near Jharsuguda, Orissa after 50 years

CONCLUSIONS

There will not be any threat to Bhedan river water being contaminated due to Ash Pond leachate through base flows. The hydrogeological, geophysical, remote sensing, water level and water quality-monitoring database, prima facie, does not predict contamination of groundwater from the Ash Pond of the captive Power Plant. The lateral migration of TDS plume during next 50 years will be in the downstream side along the stream course, which is however, falling within the boundary of assigned Ash Pond Area of Sterlite Energy Limited.

ACKNOWLEDGEMENTS

We are grateful to Sterlite Energy Pvt. Limited and Vimta Laboratories for sponsoring the study to NGRI. Interactions with officials of Vimta Laboratories during field visits is thankfully acknowledged. We wish to thank Dr. V.P. Dimri, Director for encouragement during the course of the study.

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