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EDITOR'S COLUMN

India has become one of the leading steel producers in the world with a production of 91 MT. There is enough potential for growth since the per capita steel consumption at 61 Kg is low in India, against the world average consumption of 208 Kg.

From 2011 to date, several issues have adversely affected the steel industries, ie. scrapping of iron ore and coal mine licenses, delay in acquisition of land, environmental clearance, led to many of the projects facing significant cost and time overruns. Global prices of steel plummeted in the years following 2010-11, heralding the beginning of an economic slow-down in the world steel industry. By 2015, prices had fallen by almost 48% compared to that of early 2011, their lowest in decades, as cheap imports of iron ore flooded world steel markets. The world economy has yet to recover from the slow-down of 2011.

Efforts to recover the steel market from the ensuing depression have seen a lot of buzz in the corridors of power. There was a news that South Korean steel major POSCO and public sector major SAIL would jointly set up a 3-million-tonne integrated plant in Jharkhand. Establishment of steel plants along the coast under the aegis of Sagarmala project will be undertaken. A lot of developmental projects, like: infrastructure and construction sector, initiatives for affordable housing, expansion of railway tracks, development of shipbuilding industry, allowing private participation in defence manufacture and the possible growth in the automobile industry, are expected to raise the demand for steel in India. It is anticipated that a crude steel capacity of 300 MT will be required by 2030-31, based on the demand projections as mentioned above. However, achieving crude steel capacity up to 300 MT will require extensive mobilization of natural resources, finances, manpower and infrastructure including land.

To ensure adequate availability of iron ore and other minerals, suitable efforts will be made in conjunction with Ministry of Mines to facilitate auction of mineral blocks in a regular manner. Augmentation of iron ore resources must draw the attention of exploration agencies like GSI, MECL and OMC in Odisha under the coordination of NMET to pursue exploration of prospective areas for 59 to 63% Fe grade alongwith sub-grade 45% to 58% Fe iron ore. While exploration for new resources of iron ore is under focus it is recommended to promote utilization of the not so low grade fines lying at mine sites of iron ore miners. Beneficiation industries should be strengthened through suitable support and even incentive for it will contribute in a big way to the conservation of minerals as stressed in the national mineral policy.

Dr. B. M. Faruque
Editor

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METHOD OF TUBE WELL CONSTRUCTION IN COASTAL SALINE TRACT OF ODISHA

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ABSTRACT

Tube wells are the most common water abstraction structures in the coastal areas of Odisha for extraction of ground water. Odisha has a vast stretch of coastal tract and deltaic area underlain by unconsolidated sediments deposited in a fluvial, marine or fluvio-marine environment. The granular zones form potential aquifers which are in stress to cater the growing demand of the people living in this area. Further, salinity problem has made the hydrogeological condition of the area more complicated. Unsystematic method of well construction in an unscientific manner has resulted in well failures thereby causing financial loss as well as destruction of the precious fresh water aquifers in these areas. A systematic procedure of tube well construction has been discussed in this paper.

***Key Words**: - Tube well, Saline tract, Mud rotary, Gravel pack, Saline sealing, Odisha.*

INTRODUCTION

Water is the most precious commodity on the earth's surface and is vital for sustenance of life. Both surface and groundwater play important role in the field of drinking water supply in rural as well as urban areas. Odisha a state in the eastern part of the country being bordered by Bay of Bengal has vast stretch of about 480 km long coastal tract and deltaic land of the major rivers of Mahanadi, Brahmani, Baitarani and Rushikulya. The deltaic areas being fertile are thickly populated and the water demand for domestic need is very high. Though the areas are endowed with potential aquifers, salinity problem has made the water resource scarcer. People construct water abstraction structures like tube wells both shallow and deep to exploit fresh ground water for meeting their requirement. As the aquifers in the coastal tracts are often affected by salinity, proper scientific well design and methods of well construction are required in the area for extraction of fresh groundwater.

HYDRO-GEOLOGICAL CONDITION

The deltaic areas and coastal tracts of Odisha are underlain by unconsolidated sediments comprising mainly of sand, silt, clay and gravels deposited under fluvial, marine or a fluvio-marine environment (Mahalik, 2000). The sands may be angular to sub-rounded or rounded in shape and vary in size from very fine to very coarse grain. The silts are extremely fine grained and the clays are variegated in colour and may be sticky or plastic in nature. The sediments are deposited in a cyclic manner thus forming repetition of the formations. The porous and permeable sand and gravel layers in the sequence constitute the main repository of groundwater in the area (Naik, 2008). Groundwater occurs under phreatic condition in the shallow aquifers and under semi-confined to confined condition in deeper aquifers (Fig-1). Drilling in the coastal area reveals the occurrence of fresh aquifers down to a depth of 300 m or more. The eastern part of the coastal tract close to the sea is beset with salinity problem. Saline aquifers occur at different depths under varied hydro chemical situations like fresh water aquifers overlying, underlying and alternating with saline aquifers (Fig-2). In the saline affected areas it is required to delineate the fresh water aquifers and tap them by constructing suitable abstraction structures by adopting proper scientific methods. Well construction in coastal areas comprises four or five distinct operations, such as, drilling, installing the casing, placing well screen, putting a filter pack if required, grouting the annular space to provide saline sealing and developing the well to ensure sand free pumping and maximum yield (Driscoll, 1989).

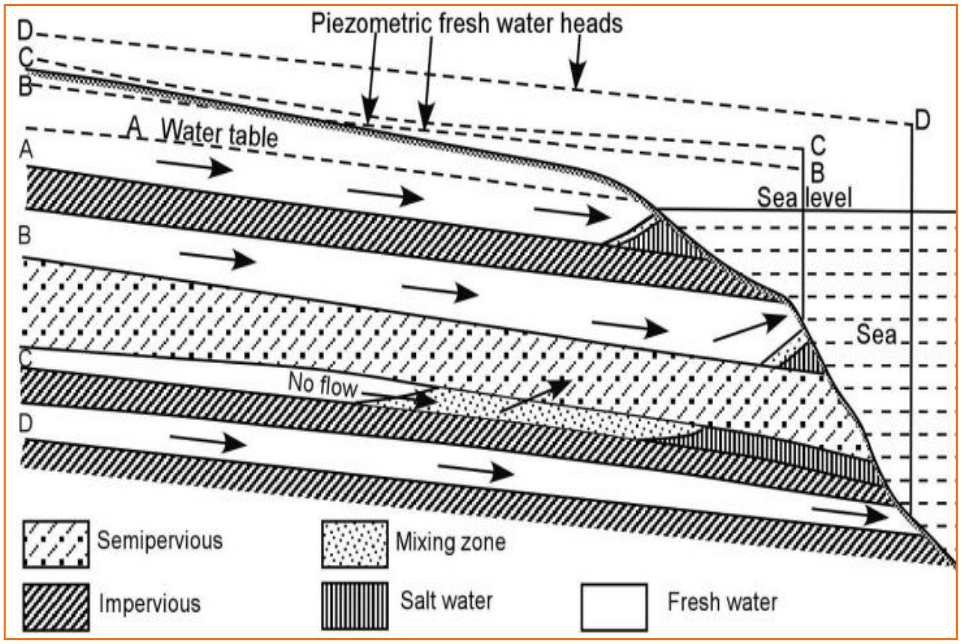

Fig-1: Aquifer system in coastal area

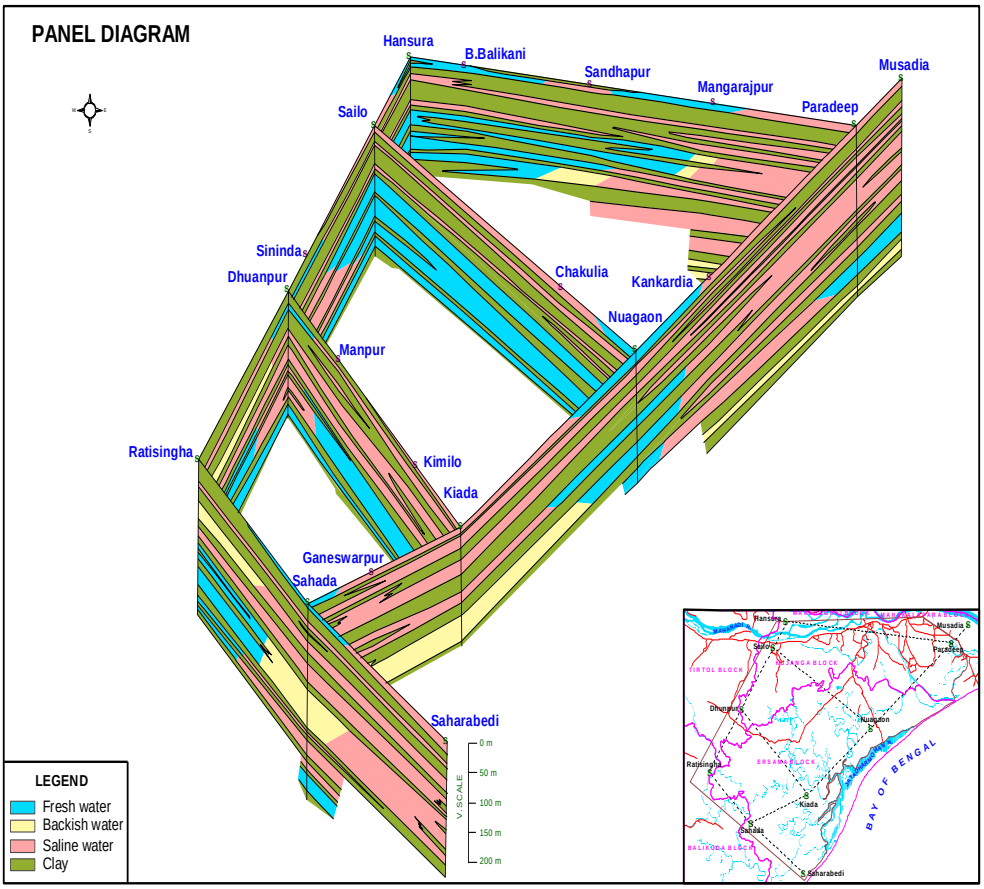

Fig-2: Distribution of Fresh-Saline aquifers in part of Coastal Odisha

METHODS OF DRILLING

Presently various methods of drilling such as Down the hole Hammer(DTH), Mud Rotary, ODEX, Combination (DTH-cum-Mud Rotary) etc are being done for construction of tube wells. Type of drilling depends on the nature of geological formations to be encountered in an area. Since the deltaic and coastal areas are made up of unconsolidated sediments, mud rotary drilling is the most suitable method for well construction in these areas. In this method the bore hole is drilled by rotating a bit and removing the cuttings by continuous circulation of a drilling fluid. Mud rotary drilling is done by two methods i.e. *Direct Mud Rotary method* (Fig-3) and *Reverse Mud rotary method*. Direct mud rotary method is mostly used in the field of groundwater exploitation. In this method, drilling fluid is pumped down through the drill pipe and which comes upward in the annular space between the hole and drill pipe carrying the cuttings. The drill fluid is channelled into a pit on the surface where most of the cuttings are settled down and the fluid is recirculated into the hole. Mud Rotary Drilling may be done by manual hand boring method or by mechanised rigs.

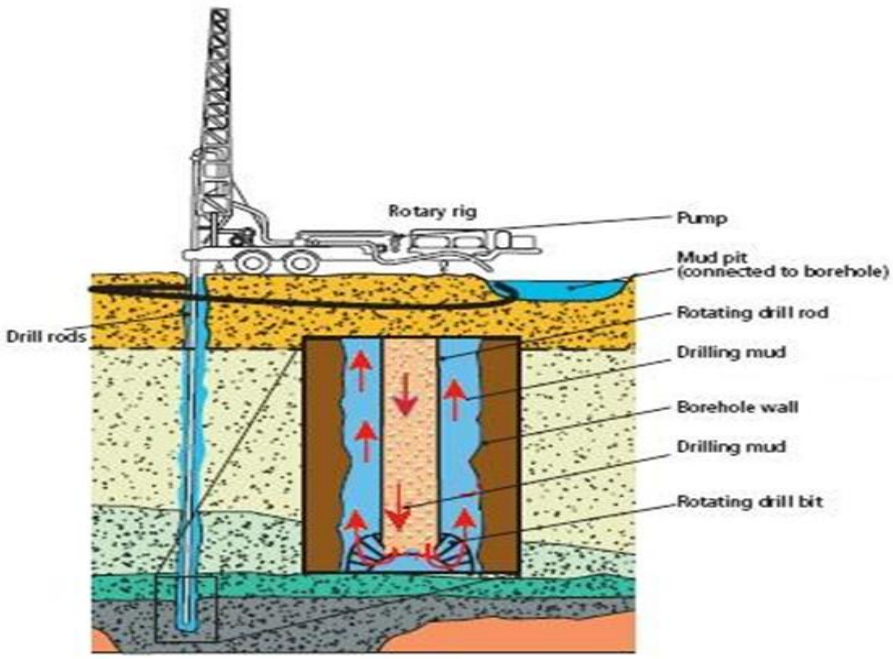

Fig-3: Schematic diagram showing Direct Mud rotary Drilling

Drilling of Pilot Bore

In the unconsolidated formations pilot boreholes are drilled first and then the bores are reamed to the required dimension and casing pipe is lowered for well construction. After selection of site the rig is placed or the stage of hand boring set is erected with precaution that traffic and electrical wires are not disturbed. In case of manual hand boring (Plate-1) the pilot bore diameter is commonly made 4” and for mechanised rigs (Plate-2) the diameter of the bore generally done 6 7/8” respectively. The construction materials like casing pipes, strainer, cement, gravel, bentonite mud etc are kept ready near the site.

Plate-1: Hand Boring Method of mud rotary drilling

Plate-2: Mud Rotary drilling by Mechanised Rig

Digging of Mudpits

Generally two mud pits namely settling pit and suction pit (Plate-3) are dug near the site. The volume of the mud in the system is most important which includes the mud in the pits and the mud in the bore hole. For hand drilling sets the volume of the two pits should be equal to the volume of the final (reamed) borehole. The volume of the settling pit shall be 60% of the volume of the drilled hole and the suction pit shall be of 40% volume. When sufficient space is available standard mud pits are used and where space is not enough for standard mudpits then reduced mudpits are done and required volume of standard mud is obtained by making the pits deeper. If the mud pits cannot be made deeper due to shallow water table then reduced mud pits may be used and the minimum volume of the reduced mud pits shall be three times the volume of the pilot bore hole.

Plate-3: Settling and Suction Mud pits

Preparation of Mud

For preparation of drilling mud one bag of bentonite (50kg) should be mixed with each 1000 litres of water. For proper mixing of water and bentonite one mud preparation pit shall be dug in which the bentonite is allowed to swell for 20 hours. After swelling, the mud is transferred into the mud pits, where water can be added to maintain the density and viscosity. Most natural waters have pH

between 5.5 and 8.5. If the bentonite is not performing well the pH should be tested and if necessary adjusted by adding soda ash or caustic soda to the mud. Sand is again an unwanted substance in the drilling fluid and high percentage of sand may damage the mud pump. The sand content in the mud should be checked regularly and if it exceeds 2% then the mud pit should be cleaned.

Drilling

A drillers log book shall be maintained at the drilling site to record length of drill pipes, drilling depth, drill time, strata penetrated, mud properties etc. Prior to drilling the drill pipes should be numbered, length of each pipe is measured and entered in the log book. The drill cuttings should be collected approximately at every 2 m interval. The samples should be kept in the sample box without washing and numbered serially. The samples are analysed and the main components and sub components are studied in detail. A litholog is prepared based on the sample analysis.

Plate-4: Drill pipes numbered and kept near the site

Plate-5: Drill Cuttings in the wooden sample Box

GEOPHYSICAL LOGGING

The coastal zone, being the transition area from land to sea and from fresh water to salt water, forms a very complex hydrogeological unit. The fresh/saline water interface boundary is complex, sensitive and dynamic and the distribution of fresh water aquifers is controlled by the dynamic equilibrium between hydrostatic heads in the fresh and saline water zones. Therefore, it is important to delineate the fresh water aquifers by applying geophysical logging techniques. Geophysical logging includes techniques of lowering sensing devices in a bore hole and recording some physical parameters that may be interpreted in terms of formation and their fluid content (Karanth, 1987). Electrical logging (Plate-6 & 7) is extensively used for groundwater exploration in coastal areas. Electrical logging is conducted in the pilot bore to record the self potential and resistivity values. These values are plotted on a graph paper to obtain the logging curve (Fig-4) based on which the fresh water zones are delineated. Resistivity of the formation depends on the nature (salinity) of water in the formation, bore diameter and drilling fluid characteristics (Lowrie, 1997).

Plate-6 & 7: Electrical logging of the pilot bore

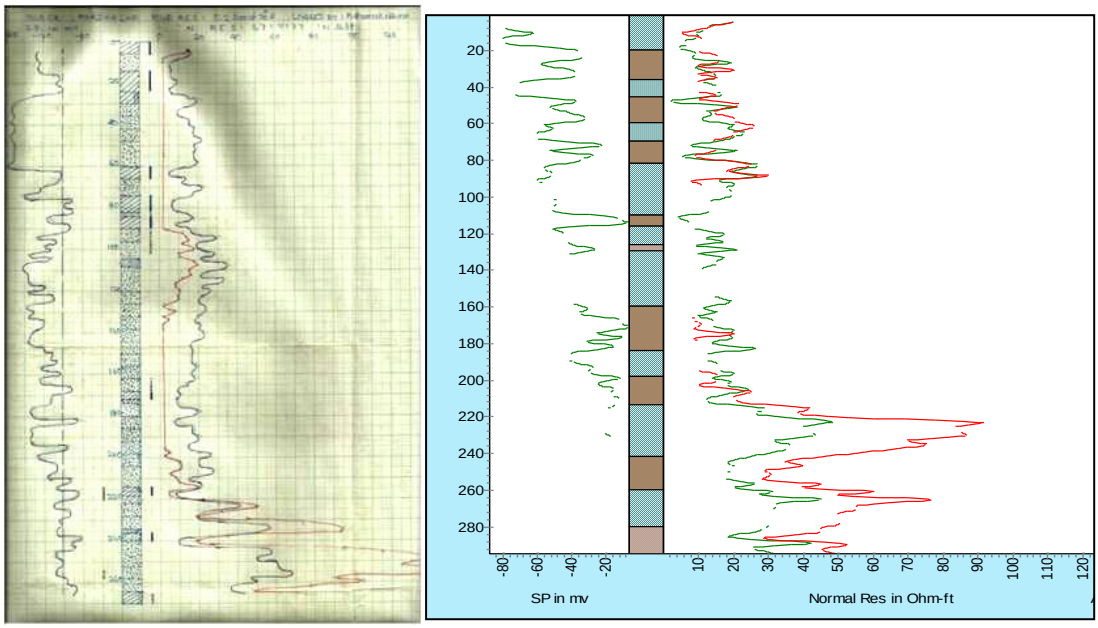

Fig-4: Electrical logging curves

WELL DESIGN

Well design is the process of specifying the physical materials and dimensions for a well. The principal objective of a perfect well design should ensure:-

- The highest yield with minimum drawdown
- Good quality of water
- Water that remains sand free and
- Well that has a long life

Though well design appears to be a simple procedure, local hydrogeological conditions and practical considerations make the process very complicated. Studying the lithological log prepared from sample analysis and the geophysical logging data the final specification of well design is made (Fig-5). The fresh water aquifer zone delineated from geophysical logging data is tapped by putting strainer pipes. If the formation comprises fine grained sands then a filter pack usually gravel packing is done in the annular space. Saline sealing is done when the fresh water aquifer is overlain or sandwiched by saline aquifers. Selection of casing pipe diameter is important because it significantly affects the cost of the structure. It is recommended that the casing diameter should be at least two inches larger than the nominal diameter of the pump. The

material of the casing and strainer may be selected based on the water quality, depth of well, cost etc. Besides, length of the screens or strainers is also an important aspect in well design which depends on the thickness of aquifer, available drawdown and nature of stratification of the aquifer. In case of homogenous unconfined aquifer the bottom one-third to one-half of the aquifer should be screened for better performance. In homogenous confined aquifer 80 to 90% of the thickness of the aquifer should be tapped.

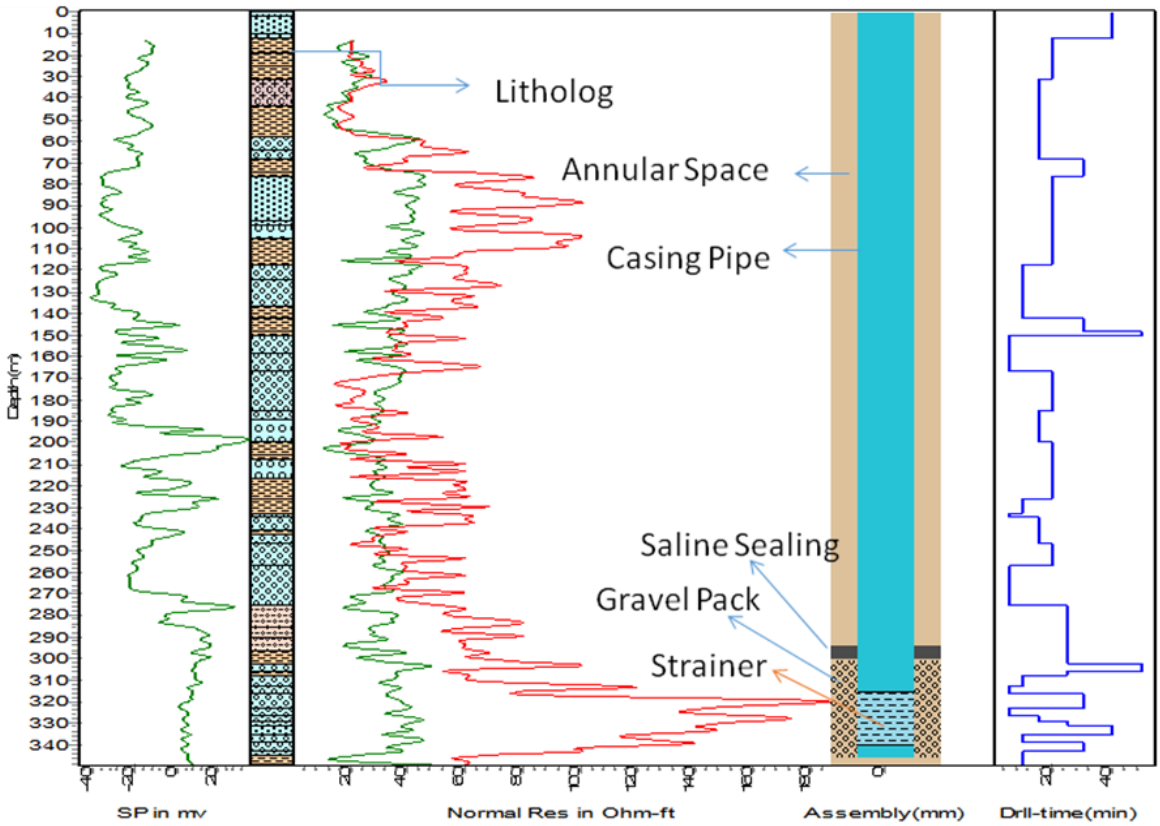

Fig-5: Well design based on litholog and geophysical log

WELL CONSTRUCTION

Reaming of Pilot Bore

Reaming is a process of widening the diameter of the pilot bore. After deciding the final specification the pilot bore should be reamed to the desired diameter. Generally the pilot bore should be reamed to a diameter at least 6” to 8” more than that of the outer diameter of the casing pipe. When the reaming has been completed the final borehole should be flushed to clear all the cuttings.

Lowering of Well Assembly

After completion of the final bore all the materials like casing pipes and strainer pipes as per well design, bottom plug and other ancillary products like Teflon tape, silicone sealant, measuring wire, centralizer etc should be kept ready near the site. The length of casing pipes and strainers are measured and kept ready as per final specification. The threads of the pipes are checked properly and jointed carefully by using O-rings, teflon tapes and silicone sealants (Plate-8) to ensure leakage proof. The mud is made thinner and well assembly is lowered up to the recommended depth as per the design.

Plate-8: Joining of pipes by using silicone sealants

Plate-9: Gravel kept to be used as Filter pack

Gravel Packing

Gravel packing is done in the annular space between the well screen and the formation material to increase the permeability and effective hydraulic diameter of the well when the formation material is highly uniform and fine grained. The size of the gravel is so chosen that it can retain most of the formation material and the well screen opening is then selected to retain 90% of the filter pack material after development. The gravels (Plate-9) should be well sorted to assure good porosity and hydraulic conductivity. Quantity of gravel should be calculated by considering the thickness of gravel pack and annular space. Calculated volume of gravels should be poured into the annular space up to the recommended depth. Leave the bore for twelve hours for the gravel to settle. Measure the depth of gravel using the measuring wire and check whether the gravel is placed at proper place. The thickness of the gravel pack should not be more than 8 inches as it will make final development of the well more difficult. Rubber packers are used when the aquifer materials are coarse in nature.

Saline Sealing

Saline sealing is put to protect the fresh water aquifer from saline water contamination from the overlying saline zone. It is done above a gravel pack base or a rubber pack base. Usually 6 m layer of cement slurry is put as the saline seal in the clay layer immediately above the sand layer to be tapped. Cement slurry is prepared by mixing 24 litres of water per 50 kg of cement. 1 or 2 kg of bentonite per bag of cement may be mixed to make the slurry flow better. The cement should be sieved and vigorously mixed to obtain a uniform slurry. Sand of 1 m thickness is poured in to the annular space at the required depth and left for one hour for the sand to settle. Then cement slurry is pumped into the annular space up to the recommended depth by using a ¾" GI pipe. Grouting should be done in one continuous operation. After grouting the bore should be left for 48 hours for curing of the slurry. Saline sealing can be checked by conducting a temperature logging in the bore. After saline sealing, back filling of the bore is done by local material.

Well Development

Well development process aims at maximizing the well yield. The broad objectives of development are: - (1) to restore the hydraulic properties of the formation lost due to drilling operation (2) to alter the physical characteristics of the aquifer near the bore hole so that water will flow more freely to the well. All new wells should be developed properly to get sand and mud free clear water before being put into operation. Various methods such as over pumping, backwashing, mechanical

surging, high velocity jetting etc. are used for well development. The well development process should continue till the water is clear and sand free.

During drilling by mud rotary method the drilling mud forms a mud cake along the wall of the bore hole between the wall and the formation which prevents the bore from collapsing. After lowering of the well assembly, this mud cake should be broken to facilitate flowing of water from the formation to the well by the process of development. Addition of polyphosphates (Sodium tripolyphosphate, Sodium hexametaphosphate) before development helps in removing the clays from the formation and in breaking the mud cake. Sodium metahexaphosphate has to be poured into the tube well through a grouting pipe to the depth where the strainer is placed. Approximately 600 gm of sodium metahexaphosphate per 100 litres of well water shall be used for the purpose. After putting the solution the bore should be left for 48 hours to dissolve the mud cake and then the well may be developed.

CONCLUSION

Fresh ground water aquifers in the coastal saline tract of Odisha are precious. Everybody exploits this resource from the subsurface by installing a large number of shallow and deep tube wells. Lack of scientific well design and proper method of well construction sometimes leads to damage of the fresh aquifers. Therefore, proper well design and construction methods should be followed strictly and public awareness may be created in these areas so that the precious fresh water aquifers can be protected for a sustainable development.

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WHETHER THE DUNE LIKE FEATURES OFF CHANDRABHAGA AND RAMACHANDI COASTS ARE REMNANTS OF PALAEO-BEACH?

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ABSTRACT

Ancient history of Odisha reveals that the Sun Temple at Konark was built on Sea. At present the Sea is situated at Chandrabhaga about 2 km away from the Sun Temple. Plenty of inverted bowl-shaped dune-like landforms are noticed within this strip of land between Chandrabhaga and Ramachandi of Puri district. Statistical analysis of grain size data of sediments of beach and dune-like landforms suggests that the dune-like features have not been produced by wind-blown sands derived from the beach, rather these are the remnants of ancient beach of Bay of Bengal, which locally attained inverted bowl-shaped forms by the action of geomorphic agents like running water.

INTRODUCTION

The Odisha state is endowed with a 480 km long shore line at the interface between the land mass and Bay of Bengal.Puri is a coastal district of the Odisha state famous for its historic antiquities, religious sanctuaries, architectural grandeur, seascape beauty and moderate climate. The length of the sea-coast of the district of Puri is nearly 150 km. Sandy ridges are found along the sea-coast formed by the strong monsoon currents which blow over the country for nearly four months in a year. The width of beach is variable within wide limits.

As revealed from the record of ancient history of Odisha, the Sun temple at Konark was built on sea (Bay of Bengal). At present the Chandrabhaga beach is situated about 2 km away from the Sun Temple in sea-ward direction which indicates that the sea has receded by about 2 km in last 800 years. There are plenty of inverted bowl shaped features away from beach in the land-ward side which resemble with dunes in geometry (Figs 1 and 2). These features may be remnants of the ancient beach or formed by wind-borne sands derived from the beach. The present study aims at resolving this problem with application of multivariate statistics to the grain size parameters of the sediments of beach and dune-like features.

STUDY AREA

The area investigated in the present study stretches from Konark to Ramachandi on both sides of the marine drive road connecting Konark to Puri (Fig. 3). It is bounded by latitudes 19° 50' N and 19° 52' 30″ N and longitude 86° 03' E and 86° 07' E forming a part of the Survey of India toposheet number E45C1 in 1:50,000. The study area is a flat land gently sloping towards east. The general elevation of coastal plain varies from 1 m to 10 m above mean sea level. As observed in the general geological set up, the Holocene fluvial and marine sands spread over the area are underlain by Tertiary beds and Upper Gondwana sediments resting over Eastern Ghats Supergroup (Mahalik, 2006). The generalised stratigraphy of the area is given in Table 1.

METHODOLOGY

In the present work, twelve sediment samples from dune-like features and six sediment samples from beach between Chandrabhaga and Ramachandi were subjected to size analysis. Size parameters like median, mean, standard deviation, skewness and kurtosis of

these samples were computed by the formulae given by Folk and Ward (1957). The formulae are given below:

Median (M_d) = Φ_{50}

Graphic mean (M_z) = $\dfrac{\Phi_{16}+\Phi_{50}+\Phi_{84}}{3}$

Inclusive graphic standard deviation (σ_1) = $\dfrac{\Phi_{84}-\Phi_{16}}{4}+\dfrac{\Phi_{95}-\Phi_{5}}{6.6}$

Inclusive graphic skewness (SK_1) = $\dfrac{(\Phi_{16}+\Phi_{84}-2\Phi_{50})}{2(\Phi_{84}-\Phi_{16})}+\dfrac{(\Phi_{5}+\Phi_{95}-2\,\Phi_{50})}{2(\Phi_{95}-\Phi_{5})}$

Graphic kurtosis (K_G) = $\dfrac{(\Phi_{95}-\Phi_{5})}{2.44\,(\Phi_{75}-\Phi_{25})}$

The Φ-values are the size values of corresponding percentiles in the cumulative weight percent scale. Φ_5, Φ_{16}, Φ_{25}, Φ_{50}, Φ_{75}, Φ_{84} and Φ_{95} are the size values corresponding to percentile values P_5, P_{16}, P_{25}, P_{50}, P_{75}, P_{84} and P_{95} respectively.

The size parameters like median, mean, standard deviation, skewness and kurtosis were subjected to multivariate statistical analysis of equality of vector means (Davis, 2002) in multidimensional space to know whether the dune-like features are the remnants of ancient beach or transported/ reworked sands of the present beach. In the former case the size parameter vectors will be equal and the difference between them will not be statistically significant while in the later case the size parameter vectors will be unequal and the difference between them will be statistically significant. The procedure is briefly outlined below:

The average mode, mean, standard deviation, skewness and kurtosis taken together can be regarded as a vector in multidimensional space, five in present case. It is assumed that the beach and dune (?) samples are represented by two separate vectors μ_b and μ_d drawn from multivariate normal populations. The null hypothesis $H_0 : \mu_b = \mu_d$ which states that the mean vector of the parent population of the beach samples is same as the mean vector of the parent population from which the dune (?) samples were taken is tested against the alternative hypothesis $H_1 : \mu_b \neq \mu_d$ by the T^2 test

$$T^2 = \frac{n_b n_d}{n_b + n_d} D' S_p^{-1} D \quad \text{where}$$

n_b = number of beach sample, n_d = number of dune (?) sample

D′ is the transpose of difference matrix (D) between beach and dune (?) mean vectors

S_p^{-1} is the inverse of pooled variance-covariance matrix from beach and dune (?) samples

The significance of the T^2 test statistic is determined by the F-transformation:

$$F = \frac{n_b + n_d - m - 1}{(n_b + n_d - 2)m}$$ which has 'm' and '(n_b+n_d-m-1)' degrees of freedom

m is the number of parameters = 5 in the present case and n_b+n_d-m-1 = 6+12-5-1 = 12

RESULT AND CONCLUSION

Size analyses of the clastic sediments are very important in sedimentological studies and have been widely used to interpret the depositional environment and mechanism in addition to conventional textural classification of sediments. The significant contributors in this field of research are Passega (1964), Folk and Ward (1957), Friedman (1961), Sahu (1964) , Visher (1969), Royse (1970) and Stewart (1958) etc.

Grain size parameters of the sediments from beach and dune-like features between Chandrabhaga and Ramachandi are presented in Tables 2 and 3 respectively.

The mean vector of the beach samples is:

Median	Mean size	Std.dev.	Skewness	Kurtosis
1.541667	1.630667	0.679167	0.181333	1.045833

The mean vector of the dune samples is:

Median	Mean size	Std.dev.	Skewness	Kurtosis
1.462500	1.488833	0.658500	0.099333	1.029583

The difference between two mean vectors (D) is:

0.079167	0.141834	0.020667	0.082000	0.016250

The pooled variance-covariance matrix (S_p) from beach and dune samples is:

0.188399	0.171857	0.020902	-0.030400	0.008947
0.171857	0.180054	0.023906	-0.021690	0.015846
0.020902	0.023906	0.009912	0.003817	0.012062
-0.030400	-0.021690	0.003817	0.022368	0.010380
0.008947	0.015846	0.012062	0.010380	0.050401

The inverse of pooled variance-covariance matrix (S_p^{-1}) from beach and dune samples is:

52.42432	-43.9583950	-19.95670	30.64631	2.978774
-43.95840	50.0080341	-24.50280	-6.76223866	-0.66241064
-19.95670	-24.5028480	281.0701	-80.5482	-39.4308
30.64631	-6.76223866	-80.5482	95.24027	-3.6519
2.978774	-0.66241064	-39.4308	-3.6519	29.70907

$D'S_p^{-1}D$ = 0.842712, T^2 = 3.370849 and calculated value of F = 0.505627

The critical value of 'F' at 0.05 significance level and with 5 and 12 degrees of freedom is 3.11. Since the calculated value of 'F' is smaller than the critical value of 'F', the null hypothesis is accepted and it is concluded that the mean vector of the parent population of the beach samples is same as the mean vector of the parent population from which the dune samples were taken i.e. there is no statistically significant difference between the size parameters of the sediment samples of beach and dune-like landforms. In geological terms, the present dune like features have not been produced by wind-blown sands derived from the beach, rather these are the remnants of ancient beach of Bay of Bengal locally attained inverted bowl shape by the action of geomorphic agents like running water.

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Fig.1. Inverted bowl shaped landform west of Chandrabhaga

Fig.2. Inverted bowl shaped landform west of Ramachandi

Table 1: Stratigraphy of the study area

Age		Formation / Group
Quaternary	:	Fluvial and marine sands
Tertiary	:	Sand, clay and limestones
Cretaceous	:	Athgarh Formation
Archaean	:	Eastern Ghats Supergroup

Table 2: Size parameters of beach sands between Chandrabhaga and Ramachandi (Panda, 2016)

Sample	Median (ϕ)	Mean (ϕ)	Std. dev. (ϕ)	Skewness	Kurtosis
B-1	2.10	2.167	0.754	0.047	1.205
B-2	2.20	2.217	0.766	- 0.024	1.025
B-3	2.20	2.250	0.726	0.031	0.984
B-4	0.90	1.017	0.613	0.327	1.101
B-5	1.00	1.100	0.593	0.255	1.076
B-6	0.85	1.033	0.623	0.452	0.884

Table 3: Grain size parameters of the sediments of sand dunes between Chandrabhaga and Ramachandi (Sahoo, 2015)

Sample No	Median (Φ)	Mean size (Φ)	Std. dev. (Φ)	Skewness	Kurtosis
D1	1.800	1.900	0.739	0.204	1.513
D2	1.450	1.417	0.623	- 0.063	0.820
D3	1.200	1.283	0.777	0.179	1.321
D4	1.450	1.433	0.621	0.092	0.501
D5	1.600	1.700	0.769	0.235	1.122
D6	1.500	1.617	0.825	0.275	1.173
D7	2.100	2.133	0.708	0.102	0.949
D8	1.350	1.350	0.533	0.059	0.929
D9	1.200	1.200	0.485	0.016	0.847
D10	1.300	1.250	0.545	- 0.036	0.929
D11	1.150	1.200	0.714	0.220	1.278
D12	1.450	1.383	0.563	- 0.091	0.973

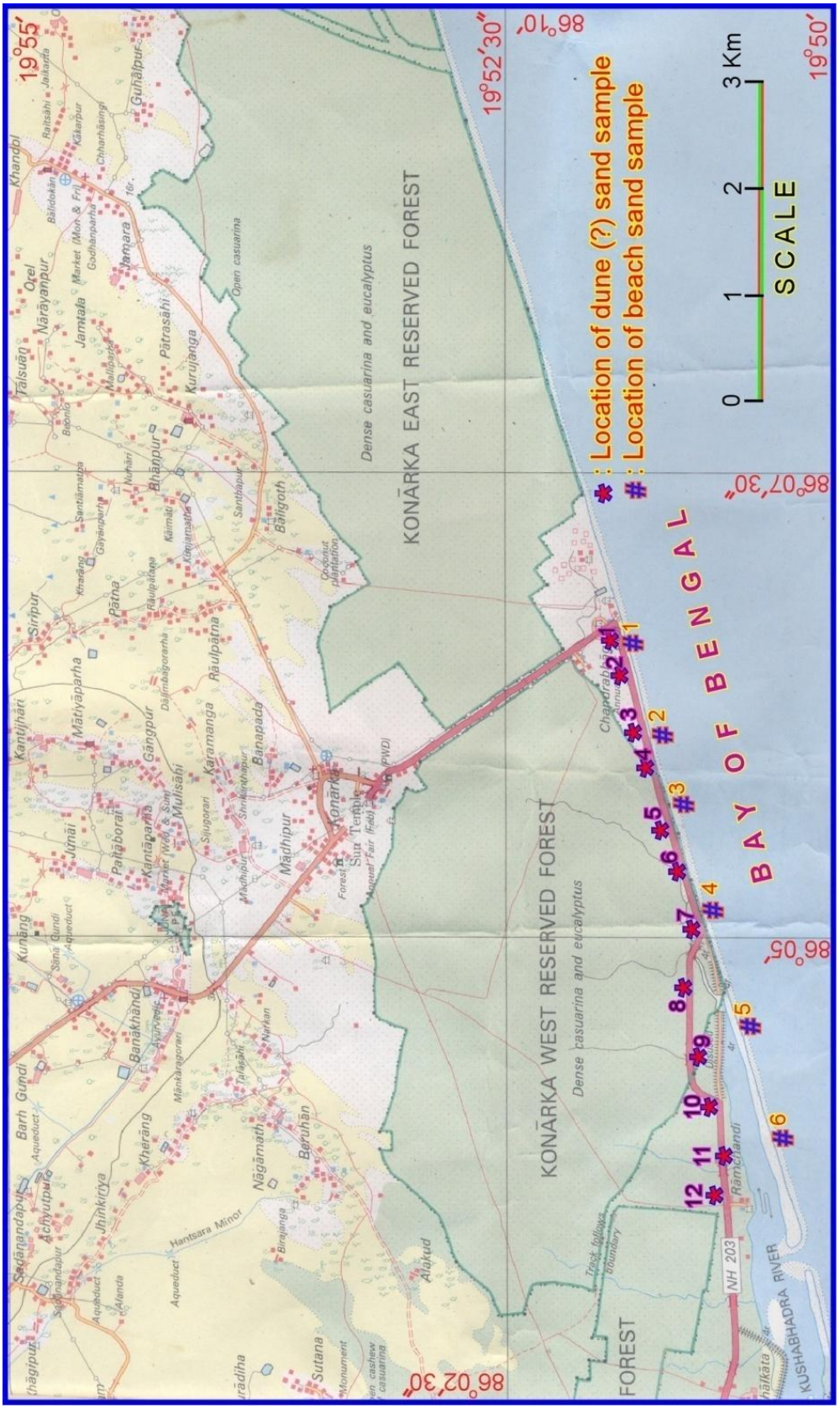

Fig.3. Map of the study area showing sample collection sites.

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HEAVY METAL POLLUTION OF AIR, WATER AND SOIL - A REVIEW

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ABSTRACT

Heave Metals have been defined and their role in life either as useful or deleterious constituent is explained. While speciation of the Heavy Metals control their mobility and bioavailability, their presence in trace level in the environment requires sophisticated techniques for detection and estimation. Sources of Heavy Metals released into environment, that is, air, water and soil, may be natural (Lithogenic) or manmade (Anthropogenic). The later, identified as Mining, Agriculture & Husbandry, Industries including Transport & Processing and Urban Settlements are the main sources that cause Heavy Metal pollution of the environment. However, the Path Way and Metal Toxicity in humans in such polluted environment is complex and yet to be properly understood.

Key words: Heavy Metals, Pollution, Toxicity.

Life Originated with Metals

The core of the earth is more than 99 per cent metal and of iron nickel alloy only. The crust of the earth is one quarter metals and seven are metallic among the ten most abundant elements. In the Periodic Table, 83 elements are classified as metals, that is, 79% of the atomic building blocks are metallic. Life has evolved amidst these lithophile elements and represents nothing but a structured architecture of these primary chemicals. It is therefore natural that coherence exists between the elemental composition of life and lithosphere except perhaps for carbon which overtakes Si in the biospheric shell because of the higher solubility of its oxide in water. While many of the abundant metals play great role in life and environment that is in biosphere, trace metals, though present in levels of part per million (ppm) or less in earth's crust, are not less significant.

Characteristics of Heavy Metals

The metals with a density greater than 5 g/cm^3 are termed Heavy Metals. An exception is As, which though lighter and non-metallic, is clubbed with the heavy metal group because its chemico-ecological effects resemble those of the heavy metals. All heavy metals have relatively smaller cationic size because of the heavier nucleus and increasingly compressed electrons. The "electron thirst" makes many of them to hanker after the loosely held outer shell electrons of sulphur thus forming sulphides as in Pb, Zn, Cu and Hg or prevents them to yield to electron hungry elements like oxygen (by oxidation) and preserve their "nobleness" as in Au, Pt, Ag etc. It is this fundamental chalcophile character of the heavy metal that threatens the sulphur atoms either in the sulphydryl group or disulphide bridge between the giant protein molecules in the living system. For instance mercaptants or "Mercury capture" known as Minamata disease is due to entry of Hg into this group (Fig.1). The ecologically more significant heavy metals Pb, Zn, Cu, Cd, As, Hg and Ni play similar disruptive role when they enter body system in higher than the required amounts.

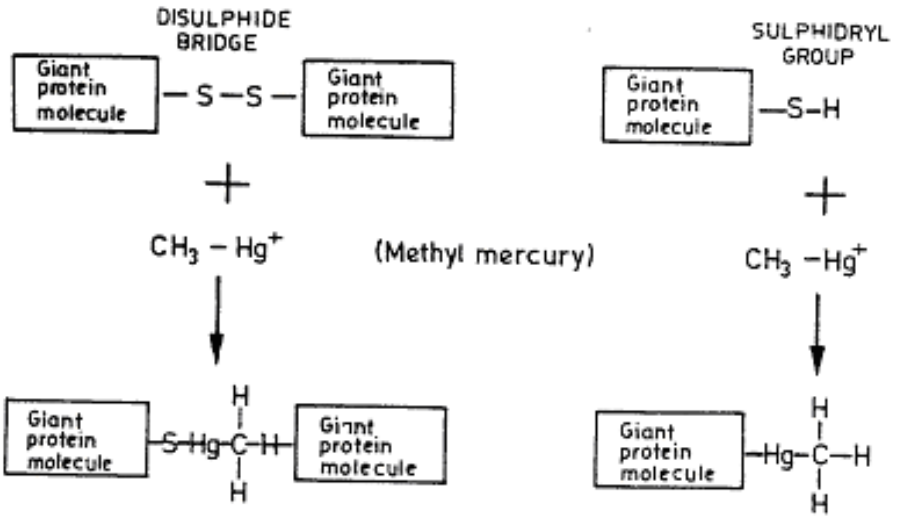

Fig. 1. Mercury Capture in Protein Molecule.

Role of Heavy Metals in Life

Many metals are useful to life (Table 1), for examples, Fe as oxygen carrier in hemoglobin, Ca and P in bone building and Mg in chlorophyll. Some heavy metals, notably Cu, Zn, Co, Cr are essential to life when present in traces, therefore are essential trace metals. They are vital in the molecular architecture of various proteins, enzymes and vitamins. However, with their increasing concentration in the environment they produce toxicity (Table 2), retard growth and result in ultimate destruction (death) of the living organism (Fig.2). Some heavy metals have no metabolic role in living cells but are found to enter (sneak into) the living organism because of their availability in the environment. Not uncommonly the functions of trace metals are intrinsically linked with one another in either synergistic or even antagonistic manner. Thus a Cu deficient diet produces anaemia while Zn and Mo can interfere with utilization of Cu. Controlled doses of Se can be an antidote to Hg poisoning since both the metals maintain an optimum ratio of "Se-Hg compartment" in living cells. While Mn in excess can cause "manganism" it can mobilize (solubilize) the inert carbon particles which are known to be seeds or nuclei of carcinogenic sites on body tissue. Thus the incidence of cancer associated with manganese deficient soils in Finland may probably be accountable. Even more elaborate relationship that can be derived (and is exploited) is powerful toxicity or "poisoning" effect of an unnecessary element like Hg in strong fungicides. The dilemma, however, is removal of the "pollutant" from environment or "fungus" from the food and water for human consumption (Horne, 1978).

Table 1: Probable role of chemical elements in life processes (Horne, 1978)
Elements necessary for life H, B, C, N, C, O, F, Na, Mg, Sl, P, S, Si, K, Ca, Mn, Fe, Co, Ni, Cu, Zn, Br, I
Elements probably necessary for life Al, Ti, As, Sn, Pb.
Elements probably not necessary for life. He, Li, Be, La, Ar, Se, Cr, Ga, Ge, Sc, Kr, Pb, Sr, Y, Zr, Nb, Te, Ru, Rh, Pd, Ag, Cd, In, Sb, Te, Xe, Cs, Ba, La, REE, Hf, Ta, W. Re, Os, Ir, Pt, Au, Hg, Tl, Bl, Po, At, Rn, Fr, Ac, Th, Pa, U.

Table 2 Threshold limit values (TLV) and toxicity of some heavy metals			
Elements	TLV (air) mg/m^3	TLV (water) µg/l	Toxicity
Cu	0.2	<1	Wilson disease, liver problem
Pb	0.15 in 8 hours	0.05	Nephritis (Kidney disease) convulsion, insomnia, headache, muscle pain, encephalopathy.
Zn	Chloride1 Zn fume5 stearate10	5	Fever, Tremor
Cd	0.1 to 0.05	0.01	Kidney damage, High BP, Cd-ring teeth, “itai-itai”, Skeletal deformation, impairment of bone marrow, aging, Carcinogenic
Hg	0.005	0.005	Neurological and Kidney damage Minamata disease (crippling)
Mo	5 to 10	<0.005	Pulmonary disorders
As	0.002 to 0.25	<.03	Dermatitis Cancer, conjunctivitis, hearing loss, Black foot disease, Hyperkeratosis.
Ni	Carbonyl 0.007, Metal	<0.005 1.0	Carcinogenic (skin), Carbonyl Poisoning
Cr	0.1 to 0.5	<0.05	Dermatitis, Skin Cancer, Perforation of nasal septum
Mn	0.3 to 10	<0.05	Parkinson disease, Manganism, Respiratory disorder, Pneumoconiosis
V	Dust 0.05	<0.1	Respiratory irritation, Cardiovascular disease, may be carcinogenic
Sn	Organic 0.1 SnO_2 10 inorganic 2	--	Pneumoconiosis – Stannosis, Neurological damage

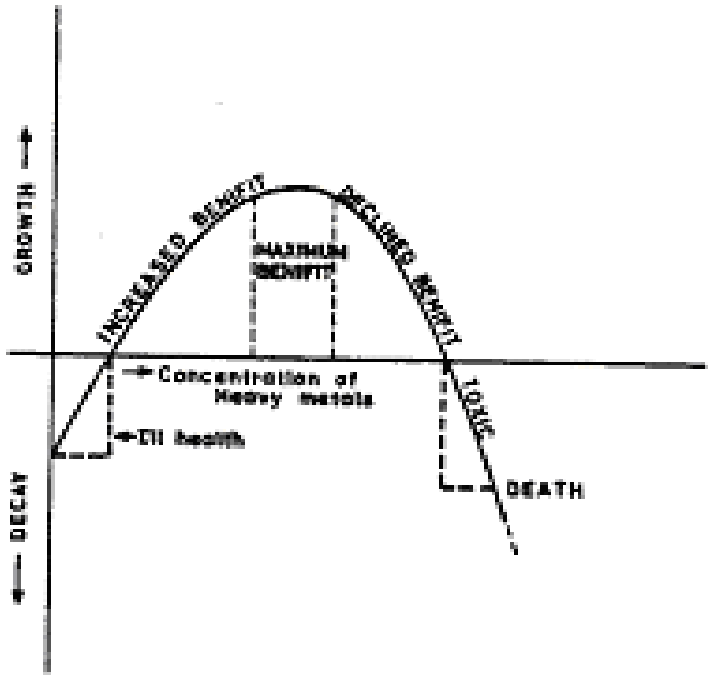

Fig.2. Heavy Metal Impact in Life (Baccini et.al.,1976)

Thus limited presence of many heavy metals at low concentration can be beneficial to humans because of their germicidal property. For examples, the "sacredness" of Ganges water is evidently due to presence of traces of copper cation derived from dispersed copper sulphide deposits in Himalayas and the traditional habit in Maharashtra to drink water, the first thing in the morning from an overnight stored copper Jug has the same meaning. Similarly, the commercial application of silver anode pencil to purify a glass of water, when dipped for a few seconds, vis a vis protection of easily decomposable cheese products like "*Burfis & Rasgollas*" with a silver foil are mere antibacterial measures, so commonly used without being aware of it.

Speciation and Bioavailability

The mobility or phytoavailability/ bioavailability and toxicity of a metal are very much dependent on its valency, state and speciation. Chemical speciation of many metals have been extensively studied and so also techniques of their determination. Copper may be present in several species. Fe^{+2} is more mobile than Fe^{+3} and hexavalent chromium is hundred to thousand times more toxic than the trivalent chromium. While organic mercury is easily bioavailable and more toxic than inorganic mercury, when it comes to arsenic the reverse is true. Some metals are more harmful in volatile forms such as those of vanadium and nickel.

The relationship between toxicity and chemical speciation is best understood by the ionic size difference between Cr^{+3} and Cr^{+6}. The former is about 0.65 A and the later, having stripped off its three more outer electrons, attains an effective cationic size of about 0.52 A. It so happens that the pores (passage) of the cell-wall being of intermediate size (>0.52 but <0.65 A), the relatively smaller cation Cr^{+6} can easily slip into the cell but not the larger Cr^{+3}. On entry, the Cr^{+6} is easily reduced to trivalent state in an anoxic cell fluid, making the exit of the resultant Cr^{+3} impossible. The chromium in the cell thus becomes carcinogenic. The carcinogenicity, producing an inert cell, is again best understood by the tanning action of chromium

where the raw hide or skin becomes an inert (durable) piece of leather.

As against the dissolved metal species, described above, the concept of solid speciation attempts to classify the presence of the metal in five different geochemical pools such as, exchangeable phase, carbonate phase, reducible phase, organic/ sulphidic phase and lithogenic (structural or lattice) phase in order of immobility. It also represents the ease of transfer of the metals from solid to dissolved state. Like the techniques of determination of the chemical species, the solid species of a metal can be analyzed by sequential extraction but with a certain amount of overlap between each stage of extraction.

Many national and international authorities have attempted to assign acceptable limits for the presence of various heavy metals in food and potable water. The limits (values) stipulated can be accepted only as guiding figures and are not absolute. For example, an urban child receives lead doses from piped water, automobile fumes, whereas a rural child has limited sources of lead intake. Therefore the drinking water standard of Pb for an urban child ought to be much lower than a rural child. Besides the stipulation of an acceptable value is based on analysis of a water sample filtered through a Millipore filter paper (only dissolved species), but no water supply can attend the removal of sub-micron particles which are normally store house of adsorbed heavy metals. On the analytical front too, the value of a standard is very much dependent on the limit of detection and allied factors. For example, in 1964 the normal acceptable concentration of chromium in human blood was 1000 ng/L but in 1971 the value dropped to 0.1 ng/L and the present day acceptable value is quoted as 0.1 to 1 ng/L.

The problems of heavy metal pollution is that, unlike other chemical parameters like pH, alkalinity, hardness, BOD, COD etc. which can be estimated in a simple laboratory, determination of heavy metals need sophisticated equipment's like Atomic Absorption Spectrophotometer (AAS), XRF, ICPS, INA etc., and the pollutants are present in ppm or ppb levels. Therefore, the problem is less highlighted, in spite of the fact that a chronic low level dose of heavy metal is more harmful than an occasional high dose.

Sources of Heavy Metal Pollution

Our biochemistry reflects the composition of the uncontaminated primeval biosphere, is attuned to the composition and dependent on it. Soil, a product of chemical weathering of crustal rocks in geological time scale, envisages an equilibrium state of most heavy metals at least within a person's lifetime. The crust of the earth has low Clarke of most of the toxic heavy metals (Table 3), immobilized in mineral constituents and their lithogenic release to the environment is therefore low. However, of late, man has turned out to be a stronger geological agent, at least locally and has brought about enormous changes in mass movements and chemical alteration in some segments of the earth's crust with consequent changes and adjustment in internal biochemistry through food chains. Mammals, unlike microorganisms, plants and insects do not adopt to marked changes in normal trace element distributions pattern and we run the risk of creating serious biochemical disturbances if we continue to allow the soil to be contaminated in the long term, with toxic trace elements which can pass into plants and then into food chain.

Table 3 Crustal abundance (Clarke) of heavy metals, their erosional and anthropogenic release in 1000 tons/yr.(Barney 1980)			
HM	Clarke (ppm)	Erosional flux	Anthropogenic flux
Cu	50	375	4460
Pb	12.5	180	2330
Zn	70	370	3930
Cd	0.15	--	---
Hg	0.02	003	0007
Ag	0.07	005	0007
Mo	1.5	013	0057
As	1.8	--	----
Ni	75.	300	0358
Co	20	---	----
Cr	100?	---	----
Sn	2.5	1.5	0166
Mn	950	440	1600

Large scale mass movement of materials by man either in the form of resources use or waste disposals and significant changes in the chemistry of the pedosphere which supports life including humans, are found to occur precisely in four different setups, namely:

- In exploration and mining of minerals and metals,
- In agriculture, dairy and animal husbandry,
- In industries, transport and processing units,
- Around urban settlements.

Mining, Smelting and Metal Processing

Mining exposes a large volume of mineral matters, originally in apparent equilibrium in earth's crust, to various natural processes like oxidation, hydrolysis, dissolution and leaching by way of increased surface area of reaction with natural reagents. Mineralized water percolating through pores and fissures in contact with ore minerals has long been known to carry enhanced levels of concerned metals and overlying soil and water in mining district (Table 4) are rich in metals and even develop flora known to be metal indicator in geobotanical prospecting.

Table 4: Heavy metal in mineralized and non-mineralized areas of Carnon river, UK (Aston & Thortnon, 1977), Ground water of USSR (Ginzburg, 1960) and in nine effluents of Rand Gold Field of South Africa (Forstner and Wittman, 1970,)

Elements	Highest permissible Levels (WHO)µg/l	Mineralized µg/l	Non-mineralized µg/l
Fe	100	195	26
Mn	500	280	09
Cu	050	515	08
Pb	050	004	1.5
Zn	5000	2000	12
Cd	10	005	01
As	15	X	x

USSR: Average Metal Contents (ppb) of Ground waters in ore districts

District	Zn at Pb-Zn Deposits		Cu at Cu- Deposit	
	Background	Polluted	Background	Polluted
Trans Caucasia	200	200-500		
Altia	10	50-300	4	20
Sayans & Kuznetzk Altu	1	40-90	1	10-100
Central Kazakhstan	80-200	300	30	130
Central Asia	----	----	20	50
Ural	----	----	30	80

Rand Gold Field (S. Africa) : Mine Effluents (in µg/l except pH)

	West Rand	Central Rand	East Rand	Normal River
pH	3.7	3.0	4.0	----
SO_4	2950	4500	340	11
Mn(mg/l)	18	41	4	0.007
Fe(mg/l)	3	124	----	0.1
Cr	20	72	----	1

Co	2250	2610	----	
Ni	1540	15900	1920	1
Cu	1220	590	60	3
Zn	4680	13200	1150	10
Cd	7	6.1	0.2	0.5
Pb	81	32	----	0.5

Large dumps of mine waste and low grade minerals, so common in many mining districts are point sources of dispersion of concerned elements into the ecosystem of the mining belt. Pyrites a common mineral in many sulphide mines produce acidic mining water (sulphuric acid) as well as ferrous sulphate, the former dissolves away and activates metals from country rock and the latter mobilizes similar cations by stoichiometric reaction with their oxides leaving iron oxides as the immobile residue.

Waste water and tailings of beneficiation plants (Fig. 3), fall out from smelting and refining stacks (Fig. 4) as well as solid waste disposal in the downstream metallurgical process contaminate the environment with heavy metals. Cadmium contamination of various eco-compartments along Jintsu river of Japan and consequent *itai itai* disease, the "Red rivers" draining out of some of the iron ore belts of North Odisha, Madhya Pradesh and Bihar, base metal contamination of rivers flowing through or out skirting lead zinc and copper belts of Rajasthan and Bihar, pollution of lake Ontario or most of the water courses of Derbyshire in U.K. are well known examples of heavy metal contamination by mining and smelting.

$$\underset{\text{Pyrite}}{FeS} + \underset{\text{Water}}{H_2O} + \underset{\text{Atmospheric Oxygen}}{O_2} \rightarrow \underset{\text{Ferrous Sulphate}}{FeSO_4} + \underset{\text{Sulphuric Acid}}{H_2SO_4}$$

$$\underset{\text{Metal Oxide}}{M^{++}\ Oxide} + \underset{\text{Ferrus Sulphate}}{FeSO_4} \rightarrow \underset{\text{Metal Sulphate}}{MeSO_4} + \underset{\text{Hydrated Iron Oxide}}{Fe(OH)_3}$$

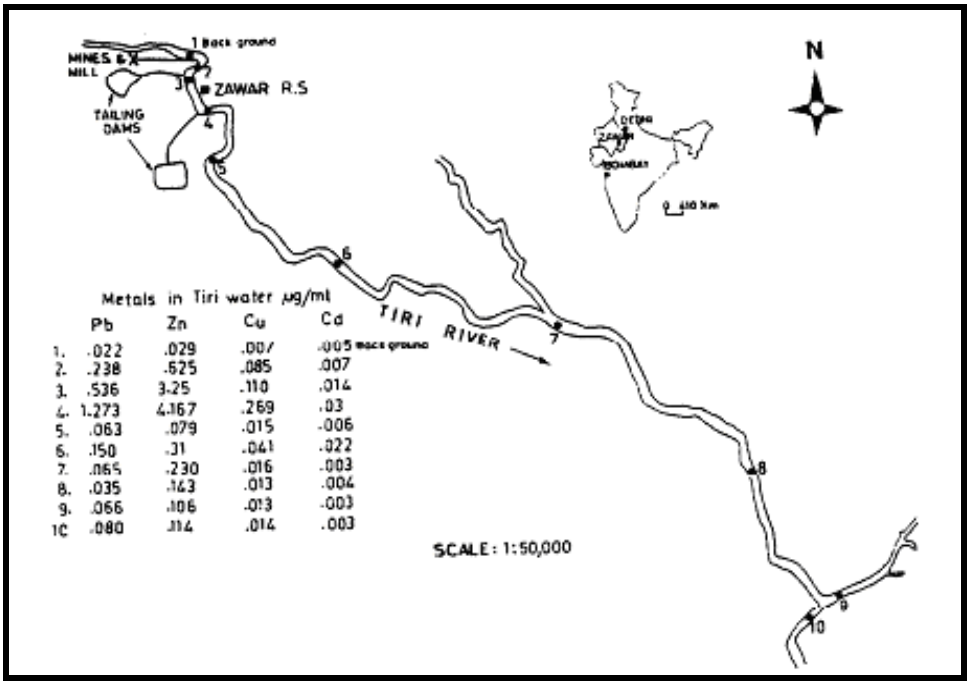

Fig. 3: Metal Contamination from Mines and Millings at Zawar, Rajasthan

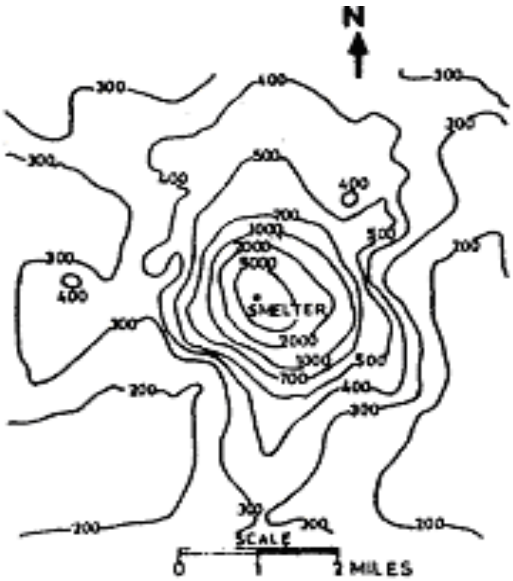

Fig. 4. Distribution of Pb in µg/g in Soil around New Lead Belt smelter in Missouri, USA (Jennett et al., 1975)

Along the long track of utility cycle of most metals, that is from mining, beneficiation, smelting, production of finished goods, use in society to recycling of scraps, there are always points of leakage (spillage) of the metal into the environment (Fig.5). Even if the degree of leakage is kept constant or at its minimum by regulatory pressures or technological achievements, the larger the production and use the greater the leakage and pollution of the environment with respect to the heavy metal concerned. Even zero waste discharge does not eliminate the leakage totally. Thus the Technophyllity Index of a metal is directly proportional to its Pollution Index making pollution a *fait accompli* for a society which heavily relies on the uses of metals.

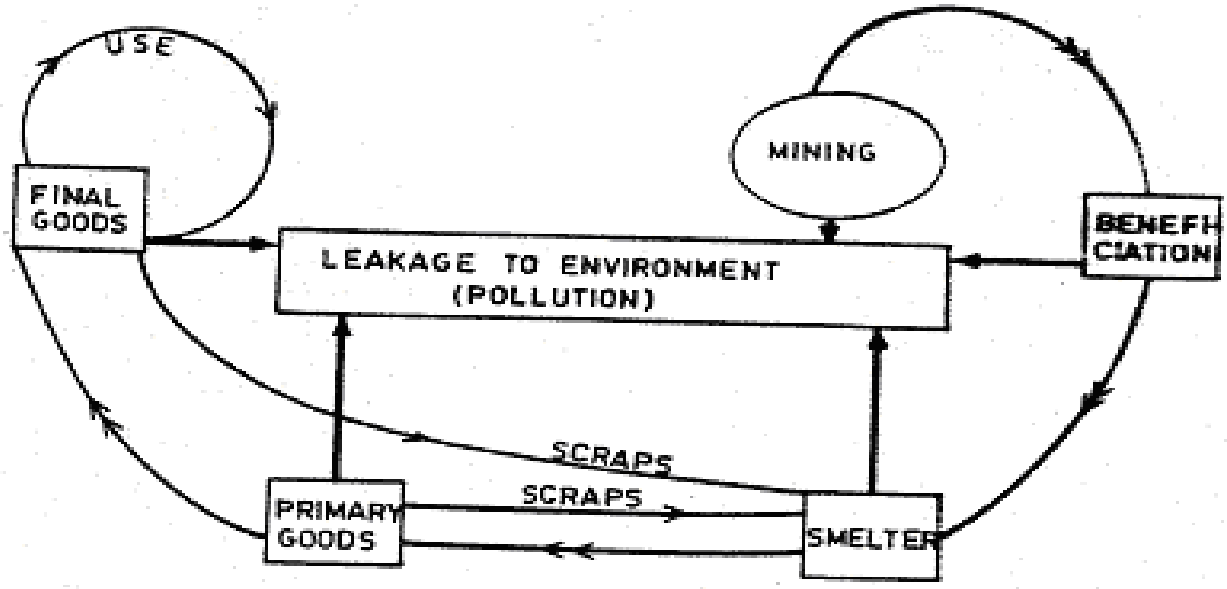

Fig.5. Pollution: Leakage of Resources from Utility Cycle.

Heavy Metals from Coal Utilization :

Table 5 Average toxic heavy metals in Coal of USA, UK, Australia (Lim, 1979) and India (*Mukherjee, 1988 and **Tripathy, 1987)(in ppm)

Elements	USA	Power plant Coal, UK	Australian Bituminous Coal	*Indian Barakar Coal	**Indian Talcher Coal
As	14.02	18.0	3	----	----
Cd	2.52	0.4	2	----	8.5
Co	9.57	---	4	----	3.5
Cr	13.75	33.6	6	23.3	50.0
Cu	15.16	----	15	119.10	14.5
Ga	03.12	----	4	82.89	----
Ge	06.59	5.1	6	20.23	----

Hg	0.20	----	0.1	30.41	----
Mn	49.40	84.3	150	----	----
Mo	07.54	2.0	1.5	575.20	----
Ni	21.07	27.9	15	13.0	38.5
Pb	34.78	38.0	10	80.23	118.0
Sb	01.26	----	20 max.	33.91	----
Sn	04.79	----	3	----	----
Ta	0.15	----	----	37.36	----
Th	02.01	----	2.7	----	16.5
U	01.6	1.3	2	---	6.4
V	32.71	7.6	20	---	----
Zn	272.29		100	114.23	38.0

A geological insight to coal formation in basins of plant accumulation indicates that the coal seams and associated sedimentary rocks like shale are repositories of many toxic trace metals (Table 5). Mining of coal brings out these metals to the surface which spread from the mine dumps by percolating water. Most coals, having deposited in anoxic environment are rich in sulphur or iron pyrites and these on oxidation on the surface produce sulphuric acids and whose metal mobilization capacity has already been discussed. It is estimated that coal mining alone brings out to the surface about 20,000 tons of uranium, 7% of worlds estimated resources (Barney, 1980), which spreads around the biosphere and whose effect is very little understood. Conspicuous consumption of coal, rich in heavy metals, in a thermal power plant can load various eco-compartments around the plant with a considerable amount of heavy metals, the magnitude of which can only be realized by detailed analysis of mass balances of all the chemical constituents. The result appears stupendous and frightening (Fig.6). Investigations show that most of the toxic metals of the feed coal, after combustion are sited within 300 Angstroms surface layer of the ash particles (Natusch et al. 1979) and therefore are vulnerable to release to the environment around thermal plants which generate millions of tonnes of ash per year. Although no confirmed toxicological damage has yet been reported around coal burning thermal plants, except the case of arsenic poisoning in Czechoslovakia (Bencko et al. 1977), scientific surveillance needs to be maintained around such ecologically fragile sites. The toxicological effect of such impacts being chronic, unlike atmospheric pollution around thermal plants, the damage function goes unnoticed and completely camouflaged by what is socio-politically known as ‘regional development’ and increased energy production.

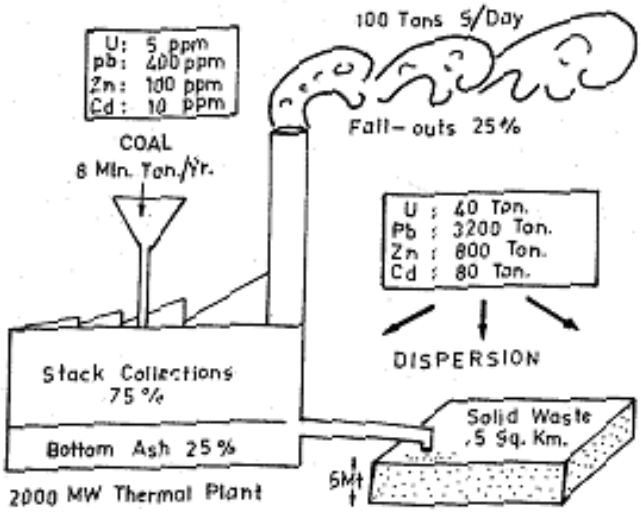

Fig. 6. Trace Metal Balance : Coal Ash to Environment

Agriculture, Animal Husbandry and Diary

Agricultural practices generate the largest amount of soil movement by way of disturbances of the top layer of the pedosphere and produce conspicuous particle and water interaction. The compost and the organic acids tend to dissolve many trace metals and either pump them (make phyto-available) into the plants or mobilize them into the percolating water in the form of soluble metallo-organic complexes.

Application of fertilizers such as rock phosphates, saltpetre, guano and slags, carrying large doses of trace metal like U, Cd, V, Ni, Se, As etc. and herbicide and insecticide add many a toxic metals into the soil (Table 6, Barrows 1966). There is no denial that Green Revolution, primed by application of chemical fertilizers and pesticides has considerably increased heavy metals in soil, water and food products, but has prevented mass hunger and starvation. That is, people in less developed countries have accepted death due to poisonous food rather than death due to starvation. Inorganic fertilizers may replace many important trace elements, and even “shot-gun mixtures” for essential trace element replacements are commercially available. However, such applications lead to soil toxicity with respect to other constituents and total dependence on such “vitamins” without which the soil becomes sterile. Disposals from animal feedlots, piggeries, dairies and breweries, molasses from sugar factory etc., besides introducing metal contaminants, increase the BOD and COD levels of the surrounding aquatic regime. The anoxic condition created encourages aquatic mobilization of many metals in the environment.

6 Principal impurities in Superphosphates (after Barrows,1966)

Elements	ppm range
Arsenic	2.2 to 12
Cadmium	50 to 170
Chromium	66 to 243
Cobalt	0 to 9
Copper	4 to 79
Lead	7 to 92
Nickel	7 to 32
Selenium	0 to 4.5
Vanadium	20 to 180
Zinc	50 to 1490

Industries, Transport and Processing

All industries produce solid, liquid and gaseous wastes which are rich in one or more of the toxic metals as shown in Table 7 (Forstner & Whittman, 1979). Movement of a variety of raw materials into the factory site for consumption and transport of the processed goods by rail, road or ship is invariably associated with transport loss which ultimately ends up in the environment (op.cit : leakage) and cannot be totally eliminated. The impact of waste disposal to the surrounding environment is today minimized by various measures such as provision of precipitators, scrubbers, treatment plants, surrogate waste disposal yards/ponds, dilution or even recycling. Except perhaps for recycling all other measures have variable quantum of impact on the content and composition of the environment. Besides occupational exposure to individuals who are close to the raw materials and finished products at the site of production, the toxic substances reach the living system around, either by accidental release or by enhancement from various types of waste discharges. The intensity of the toxic impact depends upon mobility of the toxic constituent, meteorological and terrain conditions, hydrological features as well as the scale of operation.

Table 7 Heavy metals employed in major industries (Forstner & Whittman 1979)

	Cd	Cr	Cu	Fe	Hg	Mn	Pb	Ni	Sn	Zn
Pulp, Paper mills. paperboard, building paper board mills		X	X		X		X	X		X
Organic chemicals Petrochemicals	X	X		X	X		X		X	X
Alkalis, Chlorine Inorganic chemicals	X	X		X	X		X		X	X
Fertilizers	X	X	X	X	X	X	X	X		X
Petroleum refining	X	X	X	X			X	X		X
Basic steel works Foundries	X	X	X	X	X		X	X	X	X
Motor vehicles aircraft planting fishing	X	X	X		X		X			
Flat glass, cement asbestos products etc.	X									
Textile mill products	X									
Leather tanning, finishing	X	X								
Steam generating power plants	X									

The modern transport system based either on burning of liquid hydrocarbon gasoline or diesel or on electrical energy derived from burning of fossil fuels, diesel, even nuclear reaction, has no less contribution to heavy metal enhancement or carcinogenic substances. The tetraethyl lead from gasoline, the benzopyrene from diesel engine or the radon from nuclear waste, not to speak of the controversial discharge of active hydroxyl ions and NO_x into the stratosphere by high altitude aviation threatening the ozone layer, are equally harmful to the life system in this planet. However, the pace of industrialization continues unabated because the progress of civilization cannot be reversed, even slowing down is considered stupid. After all, all of us argue that industrialization is the only panacea to meet the various demands and needs of the growing population.

Urban Settlement

Population growth and industrialization has led to uncontrolled urbanization and large scale settlements. Congregation of people results not only in gravitation of variety of consumer goods but also in generation of waste and sewerage which are normally the toxic rejects not accepted by the metabolic systems. In the absence of suitable isolation network for these "societal" discharges which normally pervade the water and soil in most cities of developing countries, the urban habitants live on the same toxic discardants in one form or other. The sprawling municipal waste dumps in and around the metropolis, the sewerage or sludge applicated garden vegetables and the atmosphere laden with automobile fumes, industrial stack emissions, domestic smokes and carcinogenic suspended particulates, all have enhanced levels of toxic metals (Table 8). Even the garden soil receiving atmospheric fallouts has been found to be contaminated with sufficient Pb so that the kitchen garden products may also be considered harmful in a home. Thus not only the "natural" food baskets of urban home has always a higher content of heavy metals, the " cocktail air" they breathe in has higher Pb and carcinogens and the tinned food stuffs that overwhelmingly supplement their daily requirements have larger doses of heavy metals and continuously change the biochemistry of the urban population. Transplacentral transfer of Pb, Hg and Cd has been noted in human foetus. Since the migrants to urban settlements are normally in their prime reproductive stage, the largest section of the earth's population (the future urbanites) run the risk of toxic metal exposure in the most sensitive stage of life, that is in the foetal state, when the teratogenic impact is maximum, permanent and beyond any recuperative mechanism of physiologic or metabolic correction. Added to this the societal habits like the lead wine vats which perhaps resulted in the extinction of the Roman civilization, we have in India, colourful " *jilebbies*" and silver/aluminum foil coated "*Barfis*", chromium coloured green peas not to speak of "vermilion beauty spots" "plumbic eyelids" or various metallic or metal coated utensils which play equal role in pumping heavy metals into our metabolic structure.

Epilogue

Man has become a major geological agent and armed with latest technological tools and vast sources of energy, is bent to change the face of the earth to his convenience. The amount of lithogenic flux developed by man, excluding that in agricultural practices is in order of 10^{16} to 10^{17} grams and surpasses any natural agents like erosion and crust mantle transformation. So also in global mobilization of metals (Table 9). The future pattern of metal emission is likely to increase and exposure to population as well. The exhaustion of known ore deposits will lead to exploitation of either new mineralized belts or lower grade ores, which mean increased metal pollution per kg. of products. Deforestation on a large scale and draining of major marsh will reduce the number of sinks available for mobilized toxic metals. Silting of water ways and agricultural soil can markedly affect the mobility. Chemical fertilizer and compost may likewise introduce unwanted metals into the soil or greatly affect the metals in soil. Increased urbanization will put more people at a risk of increased exposure to pollutants and increased consumption of processed, non-traditional food. Enrichment factor of many elements such as Pb, Fe, Cd, Zn, Cu, Sb, As, Se in urban air has been confirmed over many cities of the world. Even deep ocean and polar ice are no longer excluded from the anthropogenic inputs of metals from atmosphere (Nriagu et al. 1988).

Table 9 Industrial and natural mobilizations of trace metals in the Biosphere thousand tonnes per year (Nriagu, 1988)			
Elements	Production from mines	Total Industrial discharges	Weathering mobilization
Antimony	55	41	15
Arsenic	45	105	90
Cadmium	19	24	4.5
Chromium	6800	1010	810
Cobalt	36		120
Copper	8114	1048	375
Lead	3077	565	180
Manganese	16000	1894	4800
Mercury	6.8	11	0.9
Molybdenum	98	98	15
Nickel	778	356	255
Selenium	1.6	76	4.5
Vanadium	34	75	855
Zinc	6040	1424	540

Although considerable disagreement exists regarding pathways of exposure to metals in a multimedia context, an urgent need has been felt to recognize the short and long term effects ultimately on humans. However, it has been proved beyond doubt that body burden of many "Civilization metals" in selective metabolic organs has shown a clear increase in humans exposed to such high levels of metals all over the world.

Presently neither extensive nor any confirmatory data on metal toxicity are available in scientific literature except for a few isolated episodes like Minamata tragedy. The impact of metal toxicity rampant in developing and underdeveloped countries is camouflaged by malnutrition, poor hygienic conditions as well as effect of various other diseases and even sincere epidemiological study fails to single out a factor for the symptoms. It is also a stupendous task to determine the normal exposure synonymous to "no effect" exposure, biological sign of subclinical poisoning to severe clinical disease and death due to metal toxicity. The 'threshold health effect' casually neglected by many health officials is perhaps most dangerous since it is the low chronic dose which has disastrous teratogenic impact and goes unnoticed till it appears in a larger societal damage. Experimental verification of long term effect of low level exposure to toxic metals is a difficult proposition since human subjects are rarely candidate for study and there are still many unresolved uncertainties in extrapolating the data from animal model to human beings. Full understanding of ecotoxicology or pathological implication which can be approached in a highly abstracted laboratory setting where life processes have been severely curtailed, cannot be translated to natural real life phenomena. Interpretation of epidemiological data can also be "stylized" by scientists in process language in interjurisdictional investigation and negotiations, and conventional scientists can be severely biased.

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SUMMARY OF PROCEEDINGS OF MINEXPRO 2016

3-4 December, 2016

INAUGURAL SESSION

Delivering the welcome address **Prof. O N Mohanty**, Vice President, SGAT, submitted an account on background of the Society and its past activities. He briefed on objective and the theme of the Seminar. Prof Mohanty appreciated the contribution of SGAT towards overall mineral development of the State of Odisha.

Chief Guest of the function, Sri Prafulla Kumar Mallik, Hon'ble Minister of Steel and Mines, Labour and Employees' State Insurance, in his address expressed satisfaction that the State had auctioned its first block. The initiative undertaken by the State Govt. has attracted several investors to establish mineral based industries in the state, he spoke. Hon'ble Minister appreciated the steps taken by SGAT for organising the seminar and wished all success for achieving its aims and objectives.

Sri Deepak Mohanty, Director of Mines, in his key note address stated that in the recently concluded "Make in Odisha" conclave there was an assurance of nearly one lakh crore rupees investment in the sectors of mining and industries which was a very significant development in this mineral rich state. He revealed that the issue relating to environment-forestry versus mining is being addressed. The state has already constituted Odisha Mineral Exploration Corporation to emphasise the exploration of minerals in the state, Sri Mohanty shared.

Sri Sanjay Patnaik, President, FIMI and MD, Tata Sponge, as Guest of Honour, expressed that the enactment of legislations such as MMDR, Coal Mining Act etc has brought a clarity in this sector and may enhance more production in mining sector. He opined that some issues which need to be addressed include the necessity of private participation in mineral exploration as Govt agencies may not be adequate to undertake the mammoth unexplored area specifically deep seated mineral exploration in gold, platinum, base metal etc.; application of Geophysics and Remote sensing in the field of exploration and mining and Environmental management in mining. Mr Patnaik also emphasized on key issues like empowerment of State Govt. to release Environment and Forest clearances, appropriate and rational utilisation of DMF, Capacity building, skill development, infrastructure, CSR etc.

Sri B K Mohanty, Advisor, SGAT, during his address, emphasised on smooth mineral administration and rational utilisation of DMF. He also opined that there should be representation from scientific community in the DMF to ensure its proper utilization and National Mineral Exploration Policy (NMEP) to be investor centric.

At the end of the session Sri S K Mohanty, General Secretary offered formal vote of thanks.

Technical Session I: Innovation in mineral exploration technique and geo-spatial survey

The session was chaired by Dr O P Verma, Executive President, Indian Geological Congress; Sri R N Padhi, former Dy. Director General, Geological Survey of India and Sri J K Nanda, former Dy. Director General, Geological Survey of India. Four technical papers presented were by Dr B C Sarkar, Dr M M Mukherjee, Sri S K Jena and Sri S N Parida. Presentation was followed by discussion.

1. **Essential dimensions of Geostatistics in mineral industry: a perspective from an Applied Geostatistician:** Prof. B C

Sarkar, Department of Applied Geology, IIT (ISM), Dhanbad

Post submission of his paper, Dr Sarkar has submitted the following recommendations.

(i) India should have a dedicated Centre for R&D in Mineral Exploration in line with countries like Australia, Canada and USA who are highly ranked by Fraser. Concealed and deep seated mineral deposits need more attention in terms of target innovation and technology innovation. Nodal exploration agencies in collaboration with academic institutes like ISM and IITs need to develop a centre for R&D in Exploration.

(ii) An important advancement in the field of mineral exploration is the concept of common earth model, in which the expert understanding of a mineral deposit is captured and stored in a 3D GIS that offers potential environment to combine diverse data sets to imagine and describe geological associations in a more stable interpretative setting.

Since mineral deposits along with host lithology can be viewed as 3D objects, it is important that exploration for mineral deposits should be viewed as a 3D spatial framework to examine key spatial and characteristic associations that would govern exploration criteria for locating mineral at the deposit scale.

2. **Resource-reserve classifications – confidence and reliability:** Dr M M Mukherjee, former Dy. Director General, GSI, Kolkota

The Author, in his paper, has submitted an overview of the resource-reserve classification. Dr Mukherjee revealed that several attempts are being made by multiple agencies/institutions to create an instrument that will permit reserves / resources of solid fuels and mineral commodities to be classified on an internationally uniform system based on market economy criteria. Quantification of the error estimates of tonnage, grade and many other predictive conclusions are uncertain and this increases the potential risk hazard of an investor in development of mineral deposits. All reporting codes of resource /reserve should have transparency, materiality and competence. Mean numerical values of confidence interval of grade /quality show a very wide range. Optimisation of number of samples, minimising the standard error of estimates, compositing of samples, continuity, domaining, utmost care in usage of geostatistics, care in relating 'practical' semivariograms to the 'ideal' models, support effect, systematic approach, economic uncertainty are the crucial factors to minimise error. The nature of risks may be legal, technical, commercial, environmental, political, safety and regulatory and Force majeure. Quantified percent of risks under different headings are available as guidelines. In all major international codes of resource classification, quantification of the degree of uncertainty associated with mineral estimation is poorly addressed. Variography should not be used as a substitute for geological interpretation; it can indicate whether the geological model is appropriate. In cases of highly skewed variables geostatistical technique of estimation were unsuccessful; Field Parametric Geostatistics (FPG) that transforms noisy variograms into well-behaved variograms and justifies mathematically empirical procedures commonly used, as trimming or capping arbitrarily very high values have been advocated by resource experts.

3. **Exploration of concealed iron ore deposits within laterite covered valley area of Bonai-Kendujhar belt by structural modeling, Ghoraburhani-Sagasahi deposit of Sundergarh dist. Odisha a case history:** Mr Sarat Kumar Jena, former Dy. Director General, GSI

Author, after making the presentation, came out with following suggestions.

As the area around Ghoraburhani –Sagasahi yields a very good result due to structural modeling by GSI, similar isolated small pockets of iron ore bodies within the laterite and shale covered area of Koira valley should be looked into for detailed exploration.

Mr Jena suggested that this type of occurrence if found under the present leasehold area of any mining agency should be considered for exploration on priority basis.

4. **Iron ore potential of Odisha: scope for development of iron and steel industries in Odisha:** Mr S N Parida, Joint Director Geology, Directorate of Geology, Odisha, Bhubaneswar

Mr Parida, during his presentation, has maintained that Iron & steel industries have a bright future in Odisha on account of huge resource of high grade iron ore (haematite), flux grade limestone and adequate quantity of water. The hinterland of the state hosts adequate resource of raw material for steel making. Odisha is likely to witness rapid growth in iron ore exploitation with adoption of transparent grant of mineral concession through auction process. Quality steel with cost effectiveness has been the major objective of the upcoming steel plants. Odisha enjoys a locational advantage compared to other parts of the country. The major port at Paradip and few small ports like Dhamra and Gopalpur can cater to the trade. Efforts should be made to induct new capacity by introducing technology to meet higher quality and optimum quantity of steel requirements. Thus, in near future, Odisha is likely to become a major centre of iron and steel manufacturing state in the country.

Technical Session II: Developments in mining and mineral processing technology & Environment management in mining and processing operations

The session was chaired by Dr V P Upadhyaya, Adviser, Govt. of India, MoEF & CC, NE Regional Office, Shillong and MrSudhakar Adhikaree, Independent Senior Resource Consultant. Three technical papers presented were by Dr D S Rao, Dr G N Pujari and Mr M Choubey. Presentation was followed by discussion.

5. **Liberation characteristics of minerals from their ores:** Dr. D.S. Rao and Dr. S.K. Biswal, CSIR-Institute of Minerals and Materials Technology, Bhubaneswar - 751013

The Author presented that the study of liberation of a mineral in any ore sample is of utmost importance and helps to determine its purity by progressive crushing and grinding. The efficiency of all the beneficiation process depends on the degree of liberation. Dr Rao discussed various methods of determination and the degree of liberation of valuable minerals from its gangue with particular reference to the latest method that is QEMSCAN.

6. **Phytoremediation: a green solution to pollution by mining and smelting activities:** Dr G N Pujari, Gemfields PLC

The Author discussed that Phytoremediation is best suited for cleanup brownfield sites over a wide area in which metal contaminants are present at low to medium concentrations. As metals cannot be degraded, remediation of metal-contaminated soils requires the removal of toxic metals. Phytoremediation using metal tolerant or hyperaccumulator plants has a tremendous potential as a cheap alternative as it is effective, environment-friendly cleanup technology. During talk and in panel discussion it was suggested that Ni extraction from low grade lateritic ore should be taken up in Sukinda area using phytomining technique.

7. **Review paper – use of slag as mines stowing:** M. Choubey, S. Mitra Mazumder, S. N. Tiwari, A. Gupta, R&D Centre for Iron & Steel, SAIL, Ranchi, Jharkhand

Discussing various uses of slags the Author presented his view that slag can be utilised for different applications like tiles making, pavement etc. and as mines stowing material. After removal of free lime, it can be utilised for road making also. Dr Choubey concluded that such utility of slags leads to saving of natural resources like sand, soil etc.

Technical Session III: Statutory legislations governing mining operations in the country, Infrastructure development, trade, CSR and skill development in mining industry

The session was chaired by Mr R L Mohanty, Managing Director, MGM group & Vice President, FIMI and Mr G S Khuntia, former Executive Director (Operation), SAIL. Three technical papers presented were by Mr R N Padhi, Mr R K Sahu and Mr R N Sahu. Presentation was followed by discussion.

8. **Impediments in Foreign Direct Investment in mining sector in India**: Mr Rabindra Nath Padhi, former Dy. Director General, GSI

While discussing on the topic Author wondered as to why there is hesitation in FDI in Indian mining sector when Indian governmental policies are business friendly? Mr Padhi submitted that a very serious apprehension of most investors relates to certain geological and a few non-geological hindrances related to mostly metallic ore deposits. He expressed concern that the government is going for auction of mineral deposits on the basis of available geological exploration data from GSI and MECL, which more often are sketchy or preliminary. No mining company can start mining or even developmental mining with this kind of data. Apart from this the data available indicate poor grade and low tonnage even if there is likelihood of better tonnage and better grade in adjoining areas in a depth wise or strike wise extension. The government deciding to limit the area of auction to the known area is unwise as such restriction will limit area of exploration and not accommodative for open-cast mining. The Author suggested that as mining directly or indirectly takes care of many other activities like Agriculture, Industrial production, High-tech sectors and Merchandise production, it needs a friendlier and practical approach and we need to have people friendly rules and regulations.

9. **Role of rail logistics in the mineral development of Odisha and its future prospects**: Mr R K Sahu, Deputy Chief Operations Manager (Planning & Project), East Coast Railway, Bhubaneswar

Discussing the role of rail logistics in mineral development of the state, the Author has come out with following suggestions.

- There should be liberal sanction of land for railway projects in the forest and hilly areas to get at the minerals as much close as possible to avoid road transport which is ineffective, consuming more fuel and creating pollution. The locations are in the districts of Keonjhar, Malkangiri, Koraput and the likes.

- Working of State PCB and Forest Department should be in line with economic growth and not independent.

- Arbitrary closing of loading / unloading at railway area should stop. It affects trade and commerce.

- Fresh mapping of forest areas is required to eliminate bogus forest areas having not a single trace of forest.

- Time bound clearing system and monitoring mechanism for all infrastructure projects including mining and forestry is the need of the hour to make the projects stand on its base within a definite time frame. Be it 2 or 3 or

maximum 5 years, but let it be known to all.

- The present system of taking one clearance and then applying for another should be discontinued. All of them should be dealt in parallel to reduce gestation period. If money is required for clearances, then suitable policy need to be evolved to tackle the same and no work related to project shall be delayed on account of non-deposit of fees / charges, etc.

- Railway is now going through a fund crunch phase. It is borrowing money from non-stake holders such as LIC, etc. So, in this scenario joining of hands for joint venture with State Govt or Corporate bodies is a way forward to commission new railway projects in the state.

10. **Impact of recent mining legislations on mineral development of Odisha**: Mr R N Sahu, Mining Law Consultant

Author dwelt upon the grave impact of the MMDR Amendment Act, 2015 through which the MMDR Act, 1957 was drastically amended after its enforcement in 1958, during the course of about 6 decades. He pointed out that about 14,000 applications for Mineral Concessions (MC) i.e. for Prospecting Licence (PL) & Mining Lease (ML) are supposed to have become ineligible, consequent upon commencement of the Amendment Act w.e.f. 12.1.2015 as per provisions of Sec 10A(1) of the Amendment Act, 2015 for no fault of the applicants. He suggested that keeping the expansion of mining activities in the State in view, the State Govt. should have moved the Govt. of India to issue suitable orders within two years from 12.1.2015 i.e. by 11.1.2017 for disposal of different categories of M.C. applications. Since the period of 2 years will be expiring shortly, under the present circumstances, he suggested that the State Govt. may move the Govt. of India for suitable amendment of the relevant provisions of Sec 24 of the Amendment Act, 2015.

He mentioned that the main thrust of the Amendment Act, 2015 is that Mineral Concessions would be granted on auction of mineral bearing areas. The State Govt. have just started auctioning the mineral bearing areas. Auction of the leased-out areas after assessment of the left out mineral potential on expiry of the leases will be a matter of distant future. He expressed his apprehension that by auction process, big monopoly mine owners may thrive and grow and the small mine owners may be completely wiped out. He felt that future will testify as to whether grant of Mineral Concessions on priority basis i.e. on first-come first serve-basis, as was in vogue previously, or through auction-process, will be beneficial in the long run, in the greater interest of the State.

SUMMING UP AND VALEDICTORY SESSION

Prof O N Mohanty, Vice President, SGAT delivered the welcome address. Mr G P Mohapatra submitted a brief account on the technical sessions. Mr Arun Kumar Mishra, Vice President, Tata Steel, the Chief Guest of the session, delivered the valedictory speech. Sri S K Mohanty, General Secretary, SGAT offered formal vote of thanks.

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➢ SGAT News

- The 70th Independence Day of India was celebrated in SGAT premises on 15.08.2016. Dr S K Sarangi, President, SGAT hoisted the National Flag and addressed the members of the society.

- Based on the reports published in a section of press during the month of August'16, a team of Geoscientists of SGAT comprising Dr S K Sarangi, Mr Girija Prasad Mohapatra, Dr B M Faruque and Mr Sahid Ummar made a site visit of Puri coast in order to make preliminary study and assessment of coastal erosion. The scientists carried out elaborate ground survey at the mouth of the Mangala river, the site of erosion in 2007 north of the present river mouth and the erosion site of 9 August 2016 near Swargadwara. Society has drawn short-term, medium-term and long-term action plan for restoration of normalcy and sent its recommendations to the Govt.

- Mineral Development Awareness and Quiz Programme was organised by Society of Geoscientists and Allied Technologists in collaboration with Department of Steel & Mines, Odisha, with support of Rungta Mines Ltd, Essel Mining Industries Limited, Tata Sponge Iron Ltd during 26-28 August 2016 at Joda Valley Club. The event was sponsored by Tata Steel. Twenty two teams of different Universities participated in the programme. The programme comprised identification of rock and ore minerals and interpretation of satellite imagery by the geology students, identification of ore minerals and photographs of mining activities by the mining students, identification of ore minerals, metallurgical products and photographs of metallurgical processes by the metallurgy students and visit to Joda West Manganese mine of Tata Steel, Jajang Iron Ore mine of M/s Rungta Ltd, Sponge Iron Plant of Tata Sponge Iron Ltd, Joda East Iron Ore processing plant and Water harvesting structure. Priyanshu Pal and Soham Das of Department of Mining Engineering, Government College of Engineering, Keonjhar emerged as the overall winner of the event.Ganesh Pooja.

- Workshop on "Integrated Development of Daitari-Bamanipal-Sukinda Valley Mining and Industrial Area" was organised by Society of Geoscientists and Allied Technologists in association with Department of Steel & Mines, Govt of Odisha in Sukinda Chromite Mines of Tata Steel on 9th September, 2016. The workshop was inaugurated by Shri Pritiranjan Ghadei, Honourable Member of Legislative Assembly, Odisha. As many as nine papers covering different aspects of Sukinda valley were presented in two technical sessions. Aspects broadly including handling hexavalent chromium, extraction of nickel from chromite mine overburden, technology for developing underground mines, proving chromite reserves below a depth of 300 m and adoption of state-of-art environment management practices featured during deliberations. Shri Prafulla Kumar Mallik, Hon'ble Minister, Steel & Mines graced the valedictory session along with Shri Deepak Mohanty, Director of Mines, Odisha and Mr Vivek Patnaik, former Chairman, IPICOL. The programme was hosted by Tata Steel and was supported by Odisha Mining Corporation, FACOR, B C Mohanty & Sons, IMFA Group, Jindal Stainless Ltd and Balasore Alloys Ltd.

- SGAT was represented by Shri G.C. Das in the 12th CGPB Sub-Committee Meeting of ferrous minerals held on 19th September 2016. SGAT's views on

exploration of ferrous minerals were presented in the meeting.

- Shri Sanjay Kumar Patnaik and Shri Rajeev Lochan Mohanty were felicitated on 28.10.2016 for being elected as President and Vice-President of FIMI respectively.

- The 4th Indian Mining Day was celebrated on 1st November 2016 at SGAT Conference Hall. Mr G S Khuntia delivered a talk on "Sustainable Mining and Current Status of Iron Ore Mining and Future Road Map of Iron Ore Mining Industry in India" during the occasion.

- International Seminar MINEXPRO 2016 was held at SGAT building, Bhubaneswar from 3rd to 4th December, 2016. The seminar was inaugurated by Sj. Prafulla Kumar Mallik, Minister, Steel and Mines, Labour and Employees State Insurance, Govt. Of Odisha. Mr Deepak Mohanty, Director of Mines and Mr Sanjay Patnaik, Managing Director, Tata Sponge Iron Ltd and President, Federation of Indian Mineral Industries were the guest of honour during the inaugural session. A total of 10 technical papers covering fields of mineral exploration techniques, environment management and mining legislation etc. were presented in three technical sessions during the seminar. The valedictory session of the seminar was graced by Mr Arun Misra, Vice-President, Tata Steel.

- The 36th Annual General Body Meeting of Society of Geoscientists and Allied Technologists was held at 06.00 P.M. on 4th December, 2016. At the outset one minute silent prayer was observed to pay homage to the departed soul of Shashadhar Sahoo who had passed away on 13th April 2016 at Chennai. Prof Dr Omkar Nath Mohanty, Vice-President, SGAT welcomed the members. S K Mohanty, General Secretary presented the Annual Report for 2015-16 while T Mohanta Treasurer presented the salient features of Audited Annual Report and Income Tax Return thereof for the same period. K S Mahapatra Memorial Lecture was delivered by Dr S K Tamotia. SGAT Life Time Achievement Award, SGAT Award of Excellence, Sitaram Rungta Memorial Award, B C Patnaik Memorial Award and Best Paper Award for 2016 were conferred on Prof O P Varma, Prof G S Roonwal, Dr Sunil Kumar Tripathy, Dr Swagat S Rath and Dr K Sarveswar Rao respectively. The meeting ended with vote of thanks from Dr S C Mahala.

Participants of MDAQP 2016 arriving at Joda Valley Club on 27.08.2016 evening

Identification of samples by participants of MDAQP on 26.08.2016

Mr Pankaj Satija presenting mementoes to Participants of MDAQP 2016

Guests on dais during the Valedictory Session of the Workshop in Sukinda Chromite Mines on 09.09.2016

Sri Prafulla Kumar Mallik, Minister Steel & Mines, Govt. of Odisha addressing the delegates during the Valedictory session on 09.09.2016

Mementoes being presented to Guests after the valedictory session on 09.09.2016

Participants waiting for the quiz programme in the conference hall of SGAT during Regional EMAP of Bhubaneswar-Cuttack region on 28.10.2016

Shri B K Mohanty, Advisor, SGAT awarding students of D A V Public School, Unit-VIII, the winners of Regional EMAP of Bhubaneswar-Cuttack region, on 28.10.2016

Shri Sanjay Patnaik, President, FIMI being felicitated by Dr S K Sarangi, President, SGAT on 28.10.2016

Shri Rajeev Lochan Mohanty, Vice President, FIMI being felicitated by Dr S K Sarangi, President, SGAT on 28.10.2016

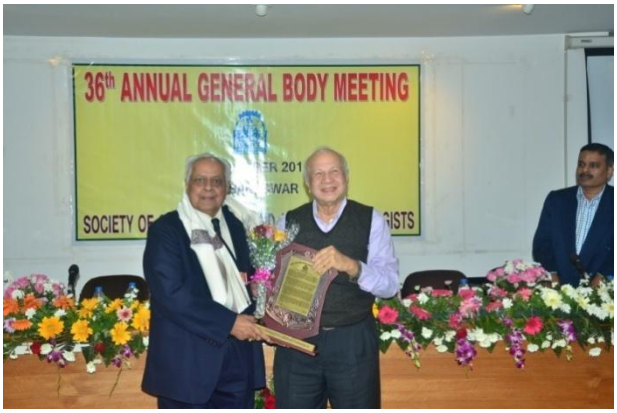
Guests being offered bouquets during the inaugural session of MINEXPRO 2016 on 3 Dec 2016

Shri Prafulla Kumar Mallik, Minister Steel & Mines, Govt. of Odisha being presented a memento during the inaugural session of MINEXPRO 2016 on 3 Dec 2016

Delegates during the inaugural session of MINEXPRO 2016 on 3 Dec 2016

Chair Persons and authors on dais during the Technical Session-I of MINEXPRO 2016 on 3 Dec 2016

Dr S K Tamotia being presented a memento by Mr B K Mohanty during the 36th Annual General Body Meeting on 4 Dec 2016



Prof O P Varma being conferred with SGAT Lifetime Achievement Award 2016 by Prof B K Sahu

Dr Swagat S Rath being conferred with B C Patnaik Memorial Award 2016 by Mr S N Padhi Former DG, Mines Safety during the 36th Annual General Body Meeting on 4 Dec 2016

Dr K Sarveswar Rao being presented the Best Paper Award by Dr M M Mukherjee, Former DDG, GSI during the 36th Annual General Body Meeting on 4 Dec 2016

➢ NEWS ABOUT MEMBERS

- Prof. B. C. Sarkar participated in the 35th International Geological Congress held at Cape Town, South Africa during August 28- September 03, 2016. Also Prof. B. C. Sarkar along with Dr S M Gandhi has published a Book on "Essentials of Mineral Exploration and Evaluation". The book has been published by Elsevier, USA (The Book is available from Elsevier Bookstore online).

- B S Pani has been elected for a term of four years as a Director to the Board of International Committee for Studies in Bauxite, Alumina and Aluminium (ICSOBA), Quebec, Canada

- Dr S. K. Tamotia has been conferred "Odisha Business Leader – Life Time Contribution to Odisha Trade, Industry and Commerce" Award on 9th Sept'2016 for his relentless effort in promotion of Industry in the State of Odisha. The award was presented by Dr. Damodar Rout, Minister for Co-operation and Excise, Govt. of Odisha.

- Haladhar Mahanta has been promoted from Asst. Manager, Liason to Manager, Liason of SAIL.

- Dr M K Somani has been transferred from Nagpur and posted as Regional Mining Geologist, Indian Bureau of Mines, Controller of Mines (N) Office, Udaipur.

- Dr. D. P. Mishra received the Hindustan Zinc Limited Prize at the 31st Indian Engineering Congress of The Institution of Engineers (India) held at Kolkata on December 16, 2016 for the paper entitled 'Evaluation of Some Parameters in Relation to Hydraulic Stowing of Pond Ash in Underground Coal Mines: A Prototype Study' published in the Journal of The Institution of Engineers (India): Series D, Vol. 96, Issue 1, 2015.

- Dr Debasish Acharya has been elevated to the post of Principal of Stewart Science College, Cuttack.

- Dr M C Dash presided the Conference on the Climate Reality Project organised by UNESCO, India office, New Delhi and Analytic Bhubaneswar at SOA University and delivered a lecture on 'Climate Change & Paris Deal'.

- Subhajyoti Das and R H Sawkar edited Special Publication No.5 ("Integrated and Sustainable Water Management: Science and Technology") published by Geological Society of India.

- Mr Anup Kumar Raut was promoted and posted as Joint Director, Geology, Zonal Survey, Dhenkanal.

- Mr Mayadhar Behera was promoted and posted as Joint Director, Geology, Zonal Survey, Berhampur.

- Mr. Saroj Kumar Sahu was promoted and posted as Joint Director, Geology, Zonal Survey, Koraput.

- The research paper "A novel approach for reduction roasting of iron ore slime using cow dung" by S.S. Rath, D.S. Rao, B. K. Mishra has been published in the International Journal of Mineral Processing, 2016, Vol. 157, pp.216–226. The research is the first ever attempt of usage of cow dung as a reductant in the reduction roasting of an Indian iron ore slime containing 56.2% Fe. The resultant reduced mass generated a concentrate of ~64% Fe with a weight recovery ~66% after being subjected to low intensity magnetic separation (LIMS).

- **NEW MEMBERS**

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- **SUBMISSION OF PAPERS FOR SGAT BULLETIN**
  (Instruction to Authors)

Research papers, review articles, short communications, announcements and letters to editors are invited on topics like geosciences, mineral exploration, mining, materials science, metallurgy, mineral industry and trade, mineral economics, environment, education, research and development, legislation and infrastructure related to mining, mineral policy and mineral development planning.

Submission of manuscript implies that the same is original, unpublished and is not being considered for publication elsewhere. Two copies, complete in all respect (with copies of figures and tables) are required to be submitted. Originals of figures and tables should be enclosed separately. Each manuscript must accompany a soft copy of the entire material prepared in Microsoft Word. The figures, if any, may be submitted in JPEG/ TIFF/ BMP format. Both the text files and figures may be written on a CD/DVD and should be submitted with the manuscript. The copies of manuscripts, strictly in accordance with the instructions to authors given below may be sent to the editor of the bulletin.

Journal Format: **A-4 size**
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The Archaean and Proterozoic terrains of South India within East Gondwana. Gond. Res. Group Mem. No.3, Field Sci. Publ., OSAKA, pp. 25-37

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