

# Environmental and waste management in some mining operations in Orissa

S.C. PANDA, R.N. KAR, P. PATRA AND B. DAS

Regional Research Laboratory, Bhubaneswar 751 013, Orissa, India

## ABSTRACT

*This paper attempts to provide a survey on environmental parameters, viz. solids and liquids collected from five different mines in Orissa. These mines are (i) Dolomite Quarry, or Gomardih (Tisco) (ii) Fireclay Mines, Talabasta (Orind) (iii) Iron Ore Mines, Joribahal (Patnaik Minerals Pvt.Ltd.) (iv) Limestone Quarry, Lanjiberna (OCL) and (v) Graphite Mines, Patnagarh (T. Pradhan). The solid samples consisted of (a) top more often the undisturbed soil near the mine, (b) the overburden/waste/spoilt dump, (c) soil from nearby paddyfield, (d) plantation area and (e) garden. These are analysed for agricultural parameters such as pH, organic carbon content, available phosphate and potassium, heavy metals such as copper, lead, zinc, chromium etc. and bacterial count. The liquid sample consisted of water and effluent collected from (i) mine pit/flow both active and abandoned, (ii) mine discharge, (iii) mineral spring, (iv) accumulated water in mines, (v) piped water in mine office and residential colony and (vi) dug well used by mine workers. These samples were analysed for heavy metals similar to solid samples, physical parameters such as total suspended solids (TSS), total dissolved solids (TDS) and the bacterial count. The analysed results were compared with the standards set by the Bureau of Indian Standards (BIS) and Central Pollution Control Board (CPCB) and recommendations on pollution control measures and strategy by other means are made for better environmental management.*

## INTRODUCTION

Mining is an important component of economic activities and is a temporary use of the land and creates a lot, more often than not, irreversible disturbances to the environment. To assess such disturbances, an environment survey was carried out during 1993-94 on (i) Dolomite Quarry, Gomardih (Tisco), (ii) Fireclay Mines, Talabasta (Orind); (iii) Iron Ore Mines, Joribahal (Patnaik Minerals Private Limited); (iv) Limestone Quarry, Lanjiberna (OCL); and (v) Graphite Mines, Patnagarh (T.Pradhan). A report on this survey was submitted<sup>[1]</sup> and this paper is an extract of that report. Prior to this, a similar survey was carried out and a report<sup>[2]</sup> was submitted and subsequently a paper<sup>[3]</sup> was presented.

## MATERIALS AND METHODS

In this environmental studies due to lack of some facilities, only two types of samples were collected. Those were (a) solid, and (b) liquid. The solids in turn consisted of (i) the top, more often, undisturbed soil near the mine and (ii) the overburden/waste/spoil dump of the mines, (iii) soil from nearby paddy field, (iv) from plantation area and (v) from gardens.

These samples were analysed for the following :

- a) Agricultural parameters such as pH, organic carbon, available phosphorus and potassium (kg/ha)
- b) Heavy metal analyses and acid insoluble, and
- c) Bacterial count

The water/effluent samples were collected from (i) mine pit/flow: both active and abandoned, (ii) mine discharge, (iii) mineral spring, (iv) accumulated rain water in the mine, (v) tap water in mine office/guest house, (vi) residential colony and (viii) dug well.

The samples were analysed for (a) heavy metal concentration, (b) physical parameters like total suspended solids (TSS) and total dissolved solids (TDS) and (c) bacterial count. The soil analyses were carried out by the State Soil Testing Laboratory, Bhubaneswar. The other analyses were carried out according to standard methods at RRL, Bhubaneswar. The heavy metal analysis was done by an atomic absorption spectrophotometer. TSS and TDS by usual gravimetric methods were done and relevant standards were consulted. The bacterial count was done according to standard procedure (dilution plate count method).

Samples were collected for three seasons, viz. Summer (May '93), Rainy July/Aug '93) and Winter (Dec'93/Jan'94). Because of various difficulties, visits to all places could not be made in all the three seasons. While Gomardih Dolomite Quarry and Fireclay Mines at Talabasta were covered for all the three seasons, two seasons (July and Dec.'93) samples were collected from Joribhal Mines and single season's samples were collected from Lanjiberna (Dec.'93) and Graphite Mines (May'93).

## RESULTS AND DISCUSSION

The analyses of the samples collected are presented in Tables-1(A, B, C) to 5(A, B, C) for the mine sites investigated. The values given in these tables are arithmetic average values for those collected in more than one season. The one season data are given as such.

**Dolomite Quarry, Gomardih, Sundargarh District**

The soil analysis (agricultural parameters) and the metal analysis and bacterial count (BC) of the soil samples are presented in Table-1A and 1B.

*Table-1A : Soil analysis (Agricultural parameters), 1993-94*

Sample No.	Location	Colour	Texture	pH	Org.C %	Le-vel	Avl. P kg/ha	Le-vel	Avl. K kg/ha	Le-vel
3	Mine top soil	Yellow	Clayey	6.33	0.076	L	45.0	H	220	M
4	OB sample No.1	Yellow	Clayey	7.23	0.08	L	53.5	H	188	M
5	OB sample No.2	Dark grey	Stoney	7.16	0.13	L	30.0	H	252	M
8	Soil from field behind garage (Private land)	Dark grey	Clayey	7.23	0.43	L	44.5	H	261	M
9	Soil from paddy field near quarry discharge point (Private land)	Yellow	Clayey	6.66	0.38	L	41.3	H	222	M

*Table-1B : Metal analysis and bacterial count of soil samples*

Sample No.	Fe	Cu	Zn	Pb	Na	Cr	B.C.
3*	3.53	0.003	0.008	0.008	0.019	0.0065	65-88
4**	8.91	0.005	0.020	0.018	0.015	0.0134	50-74
5***	9.03	0.007	0.019	0.015	0.023	0.0123	47-83
8++	5.22	0.003	0.009	0.029	0.019	0.0095	35-65
9+	5.58	0.004	0.009	0.010	0.027	0.0105	40-85

\* Mine top soil

\*\* Over burden sample from active dump No.1

\*\*\* Over burden sample from active dump No.2

+ Over burden sample from active dump No.3

++ Paddy field soil near discharge of water after oil/grease removal (Private land)

The arithmetic average values of the metal analysis, total suspended and dissolved solids (TSS and TDS) values of water/effluent samples are given in Table 1C.

Table-1C : Water/Effluent analysis

Sample No	Fe	Na	Cr	Pb	Cu	Zn	TSS	TDS	B.C	pH
	values in ppm									
1	0.12	5.0	0.016	0.20	0.00	0.006	3000	328	65-85	7.37
2	0.17	4.5	0.033	0.14	0.00	0.003	190	284	50-70	7.57
7	0.16	5.4	0.000	0.26	0.02	0.06	180	292	47-83	7.44
10	0.11	4.0	0.02	0.20	0.00	0.10	264	252	30-65	7.54
11	0.00	2.7	0.04	0.08	0.00	0.00	188	328	40-85	7.82
53	0.07	5.1	0.00	0.10	0.03	0.01	-	-	60-65	7.53

1. Water discharge from garage after removal of oil/grease
2. Mine pit water 30m deep
7. Tap water in mine office after filtration
10. Water from Nakti Nalah
11. Camp water of guest house
53. Mine discharge water

The soil pH was in the desirable limits of around 7.0. The organic content was low between 0.08 to 0.43%. The available phosphorus was in the high range i.e. 30-54 kg/ha. The available potassium was in medium range i.e. 188-261 kg/ha. Comparing with the typical concentration of essential elements and their toxicity, it was found: high iron and lead, slightly higher copper, average zinc and low sodium.

The drinking water quality was within IS: 10500 except the lead content which was higher than the permissible limits 0.1 mg/l. This needed checking and rectification. The total dissolved and suspended solids were also within or around the limits.

### Fireclay Mines, Talabasta, Cuttack District

The soil analysis (agricultural parameters) is presented in Table-2A.

Table-2A : Soil analysis (Agricultural parameters), 1993-95

Sample No.	Location	Colour	Texture	pH	Org.C %	Le-vel	Avl. P kg/ha	Le-vel	Avl. K kg/ha	Le-vel
2	O.B - 1	Whitish	Powder	5.66	0.24	L	24.8	M	183	M
1	Top soil	Blackish grey	Powder	5.43	0.20	L	31.8	M	193	M
3	O.B. - II	Reddish brown	Powder	5.55	0.08	L	14.5	M	124	M
4	O.B. - III	Grey	Powder	5.60	0.12	L	22.0	H	135	M

The metal analysis and bacterial count are present in Tables-2B and 2C. The water analysis consisting of metal concentration such as iron, sodium, chromium, lead, copper, zinc, TSS, TDS and bacterial count (BC) are presented in Tables 2B and 2C.

*Table-2B : Metal analysis and bacterial count of soil samples 1993-94*

Sample No.	Acid insol.	Fe	Cu	Zn	Pb	Cd	Na	Cr	B.C
value are in %									
2	93.73	0.24	0.001	0.004	0.001	0.001	0.013	0.031	30-55
1	91.89	0.30	0.0020	0.027	0.00	0.00	0.010	0.015	38-85
3	91.06	0.05	0.001	0.003	0.003	0.00	0.012	0.0036	38-62
4	91.37	0.41	0.0008	0.002	0.004	0.00	0.012	0.0028	40-85

1. Top soil, 2. Over burden - I, 3. Overburden - II , 4. Overburden - III

*Table-2C : Metal and bacterial count of water samples, 1993-94*

Samp. No.	Fe	Na	Cr	Pb	Cu	Zn	TSS	TDS	B.C
value are in mg/l									
70*	0.03	2.3	0.03	0.00	0.01	0.14	660	300	25-40
73**	0.59	3.1	0.03	0.00	0.01	0.12	1910	670	52-115

\* Mineral spring water, \*\* Accumulated rain water

iii) Iron Ore Mines, Joribahal (M/s Patnaik Minerals Pvt.Ltd. - PMPL)

The soil analysis (agricultural parameters) of Iron Ore Mines, Joribahal of PMPL is given in Table-3A.

*Table-2A. : Soil analysis (Agricultural parameters), (PMPL) July/December 1993*

Sample No.	Location	Colour	Texture	pH	Org.C %	Le-vel	Avl. P kg/ha	Le-vel	Avl. K kg/ha	Le-vel
21	Top soil close to ore body	Dark brown	Powdery	6.25	0.40	L	37.0	H	198	M
22	Undisturbed top soil	Reddish	Powdery	5.50	0.29	L	70.0	H	140	M
23	O.B. - I	Dark	Lumpy	6.25	0.57	M	45.0	H	163	M
24.	O.B. - II	Reddish	Powdery	5.50	0.17	L	55.0	H	172	M
25.	O.B - III	-		6.00	0.46	L	46.0	H	207	M

The metal analysis including acid insoluble and bacterial count are presented in Table-3B.

*Table-3B : Metal analysis and bacterial count of soil samples of PMPL (July/December 1993)*

Sample No.	Acid insol.	Fe	Cu	Zn	Na	Cr	Pb	B.C
figures in %								
21/61	45.50	28.27	0.003	0.0109	0.0508	0.0159	0.0114	70-79
22/62	60.90	17.59	0.00335	0.0059	0.049	0.0091	0.0244	65-73
23/63	39.40	31.27	0.0024	0.0131	0.016	0.0178	0.010	57-69
24/64	33.25	36.96	0.0018	0.0056	0.051	0.0159	0.0076	55-63
25/65	44.45	25.69	0.0029	0.009	0.0196	0.0182	0.0125	50-60

21/61 Top soil close to ore body

22/62 Top soil undisturbed

23/63 Over burden - I

24/64 Over burden - II

25/65 Over burden - III

The metal analysis, bacterial count and the pH values of water samples are presented in Table-3C.

*Table-3C : Metal analysis and bacterial count of soil samples 1993-94*

Sample No.	Description	Cu	Zn	Fe	Pb	Cr	Na	pH	B.C
Conc. value are in mg/l									
27/67	water from well No.1 Joribahal camp near Bandha	0.025	0.00	0.025	0.16	0.00	4.8	7.00	15-20
28/68	-do- Well No. 2	0.00	0.025	0.27	0.15	0.03	3.6	6.86	15-25

### Limestone Quarry, Lanjiberna (OCL)

The soil analysis (agricultural parameters) of the two overburden samples collected at the Limestone quarry, Lanjiberna is presented in Table 4A.

*Table-4A : Soil analysis (Agricultural parameters), at Limestone Quarry, Lanjiberna, December 1993*

Sample No.	Location	Colour	Texture	pH	Org.C %	Le-vel	Avl. P kg/ha	Le-vel	Avl. K kg/ha	Le-vel
57	O.B. - I	Yellowish brown	Sandy	7.0	0.30	L	51.0	H	163.0	M
59	O.B. - II	Blackish grey	Sandy	6.5	0.28	L	97.0	H	140	M

The metal analysis and the bacterial count of the overburden samples including acid insoluble are given in Table-4B.

*Table-4B : Metal analysis and bacterial count of soil samples*

Sample No.	Acid insol.	Cu	Zn	Fe	Na	Cr	Pb	B.C
Conc. values are in %								
57 O.B - I	71.71	0.00525	0.0395	11.17	0.027	0.0142	0.0037	40-45
59 O.B. -II	69.83	0.0055	0.0242	10.61	0.330	0.0090	0.0085	35-40

B.C. - Bacterial Count, O.B. - Overburden

### Graphite Mines, Patnagarh

One top soil and two overburden samples were collected at the graphite mines site of Sri T. Pradhan, near Patnagarh, Bolangir District and their analysis (agricultural parameters) are presented in Table-5A.

*Table-5A : Soil analysis (agricultural parameters), May 1993*

Sample No.	Location	Colour	Texture	pH	Org.C %	Le-vel	Avl. P kg/ha	Le-vel	Avl. K kg/ha	Le-vel
13	O.B. - I	Whitish	Sandy with stone	5.5	0.10	L	13.5	M	327	H
14	O.B. - II	Yellowish	-do-	6.0	0.12	L	9.0	L	382	H
15	Top soil	Reddish	Sandy	5.0	0.15	L	21.0	M	330	H

The metal analysis and the bacterial counts of soil samples are given in Table-5B

*Table-5B : Metal analysis and bacterial count of soil samples of Graphite Mines, Rengali, Patnagarh, May 1993*

Sample No.	Location	Acid insol.	Fe	Cu	Zn	Pb	Na	Cr	K	B.C
—————conc. values are in %—————										
13	O.B -I	71.97	9.5	0.0035	0.0112	0.0067	0.0425	Nil	0.0125	20-27
14	O.B. -II	48.70	11.06	0.0112	0.0220	0.0037	0.0017	Nil	0.0045	28-42
15	Top soil	79.15	0.39	0.0035	0.0087	0.0045	0.01	Nil	0.0077	30-36

Only one water sample from the mine pit was collected and its metal analysis and bacterial counts are presented in Table-5C.

*Table-5C : Metal analysis and bacterial count of water, Graphite mines, Rengali, Patnagarh, May, 1993.*

Sample No.	Location	TSS	TDS	Fe	Cu	Zn	Pb	Na	Cr	K	B.C
—————conc. values are in %—————											
12	Mine water	226	224	0.38	0.00	0.00	0.07	9.4	0.00	-	25-30

## CONCLUSION

### Gomardih Dolomite Quarry

The organic content of the overburden materials were low. The available phosphorus levels were mostly in the low level except a few at high and medium levels. However, the available potassium was either high or medium. The chromium content of the camp drinking water was > 0.05 mg/l. The lead content was higher at 0.26 mg/l. The rest parameters were within the permissible limits. All other parameters were under permissible/relaxable limits.

### Fire Clay Mines, Talabasta

There was no apparent seasonal change in soil pH. The organic carbon content of the top soil was above 0.20%. While that of overburden was very low as against the general level of 3% for agricultural purpose. The levels of available



phosphorus was satisfactory viz. medium to high. The level of available potassium was medium. The soil samples appears to be toxic with regard to copper, zinc, lead, and cadmium for agricultural purposes. The mineral spring water was having all the heavy metal concentrations below the permissible limits. The collected rain water sample had higher bacterial count both in Rainy and Winter seasons. The total suspended solids (TSS) and the total dissolved solids (TDS) values for accumulated rain water and for spring water were within the permissible/relaxable limits.

### **Iron Ore Mines, Joribahal**

There was no variation of pH for the two seasons studied. The organic carbon was low to medium in both the seasons and hence no seasonal variation. The available phosphorus was medium in few cases and high in the most cases. The available potassium was low to medium in rainy and medium in the winter season. The potassium concentration appears to increase in the dry seasons due to loss of moisture. The chromium content was absent for all the samples except one i.e. relating to the Tube well No.2 which was 0.08 mg/l above the permissible limit of 0.05. The iron values were in the permissible limit.

### **Limestone Quarry, Lanjiberna**

The organic carbon content of the soil was low. The available phosphorus levels were high and that of potassium was medium. In the soil/overburden samples, the copper, lead, were within the toxic limits. The values for zinc has more concentration i.e. 395 ppm and against the limit of 300 ppm. All the heavy metals such as copper, zinc and iron content in water were within the permissible limit. But the lead content was higher than the permissible limits of 0.1 mg/l. Similarly the chromium levels were in the range of 0.05 to 0.07 for drinking water and mine pit water. The MPN content of the water samples were within the permissible limits.

### **Graphite Mines, Patnagarh, Rengali**

The soil pH was low, and had low organic carbon content. The copper content of the soil was above the toxic range while other metals were within permissible limits. The metal, TSS and TDS values were within the permissible limits. The bacterial count of water was very low (25-30 MPN).

## **RECOMMENDATION**

### **Gormardih Dolomite Quarry**

Appropriate bio-fertilizer, muriate of potash are to be applied for better agricultural results.

Close monitoring of the heavy metal concentration in the drinking water at camp and the mine office is to be followed since higher than the permissible limit of chromium, copper and lead have been detected.

### **Fire Clay Mines, Talabasta**

Organic/bio-fertilizer may be applied appropriately. A minor addition of potassium and phosphatic fertilizer is needed. Further tests of the soil with respect to heavy metals are needed and these soils may be blended with soils having lower toxic metal contents. Mineral spring water is fit for human consumption with regular monitoring with respect to heavy metals content in water. The accumulated water needs sedimentation and filtration for drinking water purpose.

### **Iron Ore Mines, Joribahal**

Organic carbon content of the soil may be improved by use of bio-fertilizers. Appropriate amount of both phosphate and potassium may be applied to the soil for better agri-horticultural results. The chromium content of the Tube Well No.2 needs be monitored frequently and efforts to be made to bring this water to permissible limit of drinking water. However, this water can be directly used for other purposes viz. farm animal, fish culture, irrigation etc.

### **Limestone Quarry, Lanjiberna**

The pH of the soil samples in and around limestone quarry need be monitored regularly. Appropriate quantity of bio-fertilizer may be applied. Suitable quantity of potash fertiliser may be applied. The zinc content in the soil need reduced by blending with other soils having low zinc content. Lead content of the drinking water was higher than the permissible values and hence it should be reduced by suitable treatment. Close monitoring of chromium content in drinking and other water sources need to be done.

### **Graphite Mines, Rengali, Patnagarh**

Treatment of soils with lime may be carried out. Appropriate amount of bio-fertilizer may be applied. Appropriate amount of phosphatic fertilizer may also be applied. Soils with lower copper content may be blended with these soils. On the basis of the field visits and soil analysis of the areas, the following tree species may be planted.

(i) *Acacia auriculiformis*, (ii) *Acacia arabica*, (iii) *Eucalyptus species*, (iv) *Cassia siamea*, (v) *Cashew*, (vi) *Dalbergia sissoo*, (vii) *Prosopis species*, (viii) *Leucanea Leucocephala*, and (ix) *Bamboo*.

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## REFERENCES

- [1] Panda S.C., Kar R.N., Patra P. and Das, B., Report on Environmental Study of Some Mines of Orissa, Internal Report, RRL-Bhubaneswar, 1995.
- [2] Panda S.C., Kar R.N., Patra P. and Bhoi B., Physico Chemical and Biological Treatment of Contaminated Soils/Solids and Effluents of Orissa, Internal Report, RRL-Bhubaneswar, 1994.
- [3] Panda S.C., Kar R.N., Patra P. and Bhoi B., Environmental Survey of Some Mines of Orissa, Status and Remedy in National Seminar on Energy, Environment and Resources Development; Sastri, S.R.S., Ready P.S.R., Bhima Rao R. and Ray H.S. (Eds.) pp. 29-36, Bhubaneswar, Jan. 1995. Allied Publishers, New Delhi, 1995.
- [4] Anon., Environmental Aspects of Mining Areas, Bull. No.22, Indian Bureau of Mines, Nagpur, 1990.
- [5] Anon., National Seminar on Protection of Environment & Ecology by Mining Industry, Vol.I, II and III, Goa, Feb. 1989, Federation of Indian Mineral Industry, New Delhi.
- [6] Anon. Agriculture Guide Book, Agriculture. Inf. Wing., Directorate of Agriculture and Food Production, Govt. of Orissa, Bhubaneswar, 1991.
- [7] Bohn, H.L., McNeal B.L., O'Connors G.A., Soil Chemistry Wiley, N.Y. 1979.
- [8] Lyle E.S. Jr., Surface Mine Reclamation Manual, Amsterdam, Elsevier, 1987.
- [9] Ramanathan, N.L. and Mehta, R. (Eds.) Environmental Management of Mining Operations, Dept. of Env., New Delhi, 1982.
- [10] Sastry T.C.S., et.al., (Eds.) Plants for Reclamation of Waste lands, Pt.III, Development of Mine Wastes Land, pp.525-532, National Wasteland Development Board, PID, CSIR, New Delhi, 1990.
- [11] IS: 2296; Tolerance limits for Inland Surface Waters subjected to pollution, 1982.
- [12] IS:2488 (Part-I through V); Methods of sampling and tests for Industrial effluents, 1976.
- [13] IS: 2490 (Part-I); Tolerance Limits for Industrial Effluents, 1981.
- [14] IS: 3025; Methods of Sampling and Test (Physical and Chemical) for Water and Wastewater, 1987.
- [15] IS: 6582; Bioassay methods for evaluating acute toxicity of Industrial Effluents and Wastewater, 1971.
- [16] IS : 10500: Drinking Water, 1983.
- [17] IS: P.L. Diwakar, Pollution Control Hand Book, Utility Publishers, Secunderabad, 1986.