REPORT ON ENVIRONMENTAL ISSUES OF CHROMITE MINING IN SUKINDA VALLEY

Orissa accounts for about 98% of the total proved chromite (chromium ore) reserves of the country, of which about 97% occur in the Sukinda Valley, over an area covering approximately 200 sq. km., in the Jajpur district.

Presently there are 14 chromite mines operating in Sukinda. Out of these, one mine, Mahagiri Chromite Mines (IMFA) has started its operation of mining lumpy chromite, recently at the foot hills of the Mahagiri hill range. So far no mine drainage water has been generated. The following report pertainsto the impacts of the remaining 13 mines. Location of the mines has been shown schematically in Fig. -1(not drawn to scale).12 of these 13 practise opencast mining, while one is underground. The mines, along with their production capacities and other details are given in Table – 1.

Chromite is exported and used in the domestic market mostly for production of iron-chromium alloys (ferroalloys), which accounts for about 85% of the total chromite demand. Some chromite is also used for refractories, ceramics and preparation of chromium containing chemicals.

1. CHEMISTRY AND HEALTH IMPACTS OF CHROMIUM COMPOUNDS:

The stable oxidation states of chromium in its compounds are 3 [Cr(III)] and 6 [Cr(VI)].

Cr(III), as found in chromite and other naturally occurring minerals, is an essential micro nutrient for maintenance of normal glucose metabolism.Chromium deficiency can lead to insulin circulation and cardiovascular problems. There arereports that even relatively large doses of Cr(III) do not induce any harmful effect, when fed in water or food to animals. The portion which is not absorbed in the gastrointestinal tract is excreted.

It is believed that Cr(VI) is formed only by human activities, which is rapidly reduced to relatively harmless Cr(III) in acidic solutions ($pH < 4$) by organic matters like humus or biomass. Cr(VI) beyond a certain concentration, is toxic, inducing such symptoms as skin ulcers, vomiting, diarrhoea, gastrointestinal bleeding leading to cardiovascular shock. It is cytotoxic, mutagenic and carcinogenic.

For long, the chromite matrix was considered to be quite stable in the Cr(III) state. However, recent studies reveal that Cr(III) lodged in the chromite, can get oxidised to toxic Cr(VI), though various physico-chemical and biological processes. Chromite mineral can occur either in the lumpy or friable form. It has been observed that generally Cr(VI) problem is associated with the mining of the friable mineral.

2. ENVIRONMENTAL PROBLEMS OF CHROMITE MINING:

❖ **Presence of Cr(VI) in mine drainage water:**

Opencast chromite mining generate huge volumes of seepage water. Eventhough chromium in chromite is in the trivalent state, some hexavalent Cr(VI) is always formed due to certain complex reactions. If Cr(VI) containing mine drainage water is released untreated, can severely contaminate the nearby water bodies.

Many mines have chrome ore beneficiation (COB) plants, where chromium content in the ore is concentrated through washing and sorting. Washings from the COB plants can also be a source of Cr(VI).

❖ **Overburden generation:**

Opencast chromite mining generate enormous quantities of overburden (OB). The stripping ratio varies from 1:5 to 1:10. Unless managed properly, run offs from the OB dumps have the dual potential of polluting the water bodies by siltation and leaching of Cr(VI).

❖ **Dust generation:**

Huge amounts of dust is released during mining, stacking and loading. The dust is, though mostly, chromite particles, may also contain traces of Cr(VI).

❖ **Loss of forest:**

Unfortunately chromite bearing mines occur mostly in forest areas. There is thus an inevitable loss of some forest cover due to mining.

3. PRESENT ENVIRONMENTAL MANAGEMENT BY THE MINES:

3.1: Mine Drainage Water

The State Pollution Control Board recorded the occurrence of Cr (VI) in the mine drainage water of the chromite mines in the Sukinda Valley in the late eighties. No techno economically viable treatment method for Cr(VI) was available then. Subsequently with the technical know-how from the National Environmental Engineering Research Institute (NEERI), the TISCO mines first adopted the ferrous sulphate reduction method for treatment of Cr(VI) bearing mine drainage water.

As can be seen from Table – 1, out of the 12 opencast mines operating in Sukinda, Cr(VI) containing mine drainage water is a problem in 9 mines. Mining in the Sukinda (IMFA), Kaliapani (Balasore Alloys) and Sukrangi (OMC) being confined to the upper benches, generate very little drainage water, which is almost completely used for sprinkling the haulage roads, without any discharge to outside. Nevertheless, all the 12 mines have a treatment system in place. Mines which have COB plants recycle there waste water.

Table – 2 describes the quality of mine drainage water, in terms of Cr(VI) concentration, being discharged to the Damsala river, directly or indirectly, over the years. Results presented in the tan place, though there is occasional deviation from the prescribed standard of 0.10 mg/liter. Such occasional violations are not uncommon in industrial and mining activities and it is not unique in case of the chromite mines in Sukinda. They occur mostly due to management lapses. However, in view of the potential toxic nature of Cr(VI), it is imperative that surveillance by the State Pollution Control Board be intensified with frequent surprise inspections and monitoring. In an interactive meeting with the representatives of all the 12 mines, it was impressed upon the managers that under no circumstances, mine drainage water and / or tailings from the COB plants would be discharged to any water body bypassing the treatment system. If under any emergency, this becomes necessary, pumping of the mine drainage water must stop immediately.

It is observed that seepage water gets accumulated in the non operating quarries in some of the mines. This is used by people for bathing and other purpose. The mine authorities have been instructed to take effective steps like putting boards with appropriate notice and fencing, if possible, to prevent people from using such accumulated water, as well as the mine discharge water before reaching the treatment plant.

3.2: Management of Overburden (OB)

As stated earlier, opencast chromite mining generate large quantities of overburden. Proper rehabilitation of the OB dumps is essential to prevent run offs carrying silt and Cr(VI) to water bodies. This is usually achieved by stabilizing the dumps with plantation, fixing of mats and construction of retention walls. One mine, Sukinda – IMFA, has constructed a garland drain, provided settling pits and has arrangements for treatment of the run off water.

The overall OB management status in the 12 mines are given in Table – 3. All the mines have an active OB dump (currently in use) and many have one or more old dumps. The mines are in the process of stabilizing the old dumps. Some mines are also progressively stabilizing the active dumps. Except in a few cases, OB management in the area, in general need further improvement. In case of active dumps, steps should be taken to stabilize the lower slopes of the unused faces.

The OB of Sukinda chromite mining contain nickeliferous laterite and low grade chromite ore. As such, the mining companies are not inclined to grow big trees on the OB dumps, since it is possible that sometime in future, appropriate technology would be developed for extraction of nickel and enrichment of chromite from these dumps.

The mines have been advised to avoid plantation of fruit bearing trees during rehabilitation of OB dumps without a detailed investigation on the likely accumulation of Cr(VI) in the fruits.

3.3: Air Pollution

Major air pollutant in mining areas is dust, generated in course of a number of activities associated with mining.

Due to changing contours of the mining pits, the haulage roads inside the mines are never made concrete or black topped. As a result, the roads are a main source of dust. This problem is addressed by continuous water spraying. It is understood from many of the mines managers that they can not afford to be lax about it, since the transporters refuse to operate without water sprinkling.

The public road approaching the valley, as well as inside, is in a deplorable state with huge potholes, adding significantly to the dust load in the area. This requires urgent attention.

In a project sponsored by the Ministry of environment and Forest during April 2004 to April 2005, the ambient air quality was monitored at 15 locations in the valley. The results are given in Tables 4 and 5. Suspended particulate matter (SPM) levels determined subsequently during 2005 to 2007 at different locations are given in Table – 6. As can be seen in the data given in the three tables, except occasional violations, the ambient air quality in respect of four parameters – sulphur dioxide, oxides of nitrogen, suspended particulate matter and respirable particulate matters, remain within the prescribed standards.

4. Cr(VI) IN DIFFERENT WATER SOURCES:

During April 2004 to April, 2005, 164 water samples from 41 drinking water sources (tube well, bore well, dug well) in the valley were analyzed for Cr(VI). The results are presented in Table – 7. Subsequently 24 analyses from 15 such sources were carried out more recently (September – December, 2007). The data are given in Table – 8. From these two tables, it is seen that water of 7 sources contains more than the permissible limit for Cr(VI) for drinking water, i.e., 0.05 mg/liter (Bureau of Indian Standards). In terms of the number of samples, out of 188 analyses, 17(9%) deviated from the prescribed standard. The concerned authorities have been instructed to take steps to ensure that people don't use the water from these 7 sources.

It is important to note that Cr(VI) concentration in the ground water sources show considerable temporal variation, presumably because of some complex hydrageological dynamics. Hence, acceptance of a particular source as suitable (with respect to hexavalent chromium) should not be taken as the last word.

Besides the aforementioned drinking water sources, water samples from a pond and a natural stream in two villages close to mining activities were also analyzed for Cr(VI). These water bodies are used by the villagers for bathing. Both the sources have Cr(VI) content much less than the maximum permissible limits for bathing water.

The Damsala rivulet crosses the mining belt along the length. This being the main source of water (at least during the earlier days), settlements and villages have developed around this rivulet. Damsala, carries the mine drainage water from almost all the mines. Water samples collected from various points of the river, starting from the site with no mining activity to the downstream of all the mines, show marginal increase in Cr(VI) concentration, but is still within the stipulated standards for drinking and bathing water. It should, however, be borne in mind that the water quality of Damsala river with respect to Cr(VI) is governed by the quality of discharge of the treated mine drainage water (Tables – 9 and 10). Failure of any one treatment system may result in a considerable increase in the Cr(VI) concentration. Apart from the hexavalent chromium problem, Damsala, like any other natural water body, could also be polluted otherwise, particularly due to decomposition of the detritus of plant materials and open defecation. It should not therefore be straight away used as a source of drinking water without treatment.

5. HEALTH STATUS:

A study was conducted by the Orissa Voluntary Health Association (OVHA), Bhubaneswar, under the Indo-Norwegian Orissa Environment Programme, some time during 1993 – 94, to assess the health impacts due to chromite mining. This is perhaps the first and by far the only such documented report. A random sample of 188 households, out of a total 373, in the villages near four chromite mining areas in Sukinda (Kamarda, Saruabil, OMC and TISCO) was selected for the study.

Besides clinical examination assess the mining impacts on skin, mucus membrane, respiration and smell, a cancer check up camp was organized by OVHA in collaboration with Acharya Harihar Regional Cancer Research Institute, Cuttack (than known as Acharya Harihar Regional Centre for Cancer Research & Treatment), in which 400 persons from a cross section of the community of the nearby villages were examined.

The following conclusions have been drawn from the study and the health camp (quoted verbatim).

- ❖ *Morbidity, which is the most important and sensitive indicator of ill health, reveals something starting in findings. In the morbidity pattern it shows a great variance between certains chromium induced diseases xxx. It is concluded that the problem pattern is not independent of the study and control.*

- ❖ *Only one case was diagnosed with "further evidence is needed to confirm the disease cancer".*

- ❖ *Based on the study findings, both quantitative and qualitative, it is quite cumbersome to reach to a definite and tangible conclusion that the chromite pollution in the mining and processing industries is acute.*

In the health camp, 10 cases of chromite related diseases (other than cancer) were diagnosed. The report recommends a further detailed study to arrive at definite conclusions on the impact of chromite mining on human health.

In February, 2004, a cancer detection camp was organized by the Indian Metals & Ferro Alloys Ltd., (IMFA), in which 227 persons from 6 nearby Gram Panchayats were examined. 4 persons were suspected of cancer - one each for breast, tongue, mouth and uterus cancer. In December, 2004, a TB detection camp was also organized by IMFA. Out of 354 persons (from 8 nearby Gram Panchayats), 58 suspected patients were examined, but no TB case was detected.

In view of such scanty and inconclusive reports, it is necessary that a detailed study be undertaken to assess the real magnitude of the health impacts of chromite mining on human health.

Recently the State Pollution Control Board has engaged Dr. B. N. Mohapatra, an Occupational Health Consultant of Bhubaneswar, for a preliminary survey on the health status of the workers and inhabitants of adjoining villages.

6. CONCLUSION AND SUGGESTIONS:

Because of operation of several mines, over a somewhat limited area, certain environmental problems are inevitable in the Sukinda valley, like any other mining area. The problem is further compounded by two issues, unique to chromite mining - generation of large quantities of OB and the problem of hexavalent chromium.

Chromite being an important natural resource of the state, mining can not perhaps be totally abandoned. With sound management policy, adverse environmental impacts can be mitigated to a large extent.

Presently, though there are still many areas which require further improvement, the overall management is reasonably satisfactory and the situation is not as bleak as is generally made out.

The following actions are suggested to ensure proper environmental management of the area.

Short Term – Requiring Immediate Attention:

1. Stabilization of OB dumps more urgently than hitherto practised.
2. Improvement of the public roads
3. Frequent monitoring of all drinking water sources for Cr(VI) and immediate closure of the sources showing Cr(VI) in excess of the permissible limits.
4. There are some quarries which are not allotted to any mining company and are not in use. Accumulation of seepage in such quarries is an environmental threat. Some agency should be entrusted with the responsibility of their proper management to ensure prevention of the untreated accumulated water going to any water body.

Long Term:

1. Feasibility study for one or more (sector wise) common effluent treatment plant (CETP). The mine water after the usual treatment by the individual mines, may be taken to a final CETP to further reduce the Cr(VI) content before discharge to Damsala. It is possible that a zero chromium level can be achieved by this. This will serve the dual purpose of protecting the rivulet as well as availability of large volumes of water, which can be gainfully utilized in this water starved area.
2. Cr(VI) concentration in ground water sources fluctuate over time. Hence to ensure continuous supply of safe drinking water, feasibility of a total prohibition of extraction of ground water in the valley and use of inland surface water (Damsala in the uncontaminated upper reaches) for supply of drinking water may be investigated.
3. A detailed survey by an eminent expert body, to assess the impact of chromite mining in the area on human health.

Above all, there should be continuous surveillance by the State Pollution Control Board with frequent surprise inspections and monitoring.

7. COMMETNTS ON SOME RECENT REPORTS ON SUKINDA

In September, 2007, one Blacksmith institute of US has come out with a report giving a list of top 10 severely polluted places of the world. The list includes Sukinda. As expected, the report was given wide coverage in almost all the state and national level media, without most of them bothering to verify the veracity of the standards made in the report.

It is therefore considered appropriate that each of the issues raised in the Blacksmith report be put in perspective based on scientific facts and observations. The report apparently relies heavily on secondary and tertiary information. Most of which are hearsay and quoted out of context.

Waste rocks (meaning perhaps the overburden) are spread over Brahmani river banks and untreated water is discharged by the mines into the river.

Brahmani is too far away from Sukinda to have waste rocks dumped on its banks. The main natural stream flowing through Sukinda is Damsala. As indicated in Sec.3.1, all the mines have a treatment system. Treated mine drainage water, meeting the prescribed standard (except occasional deviations) is discharged to Damsala, the water quality of which generally remain within permissible limits with respect to Cr (VI). Damsala joins Brahmani river through another small tributary (Ramiala). No detectable amount of Cr (VI) is found in the downstream of the confluence of Ramiala with Brahmani, though there is a small increase in the total chromium concentration.

Approximately 70% of the surface water and 60% of the drinking water contains hexavalent chromium of more than the double national and international standards and levels of over 20 times the standard.

Out of 41 drinking water sources monitored for presence of hexavalent chromium during 2004 – 05, four (10%) ware found to contain Cr(VI) above the permissible limits. A similar exercise during September – December 2007 indicate contamination of four sources out of 17 (24%) (Sec.4) in all cases except three, the deviations being 1.2 to 6 times the standard.

Chromite Mine workers are constantly exposed to contaminated dust and water. Gastrointestinal bleeding, tuberculosis and asthma being common ailments. Infertility, birth defects and still births have also resulted.

Suspended and respirable particulate matters in the Sukinda valley generally remain within the prescribed norms (Sec.3.3). The diseases named above, could result due to intake (oral or inhalation) of excessive Cr (VI). But, no authentic report based on any survey has been quoted to show that they are actually acute in Sukinda, compared to other areas.

The OVHA reported that 84.75% of the deaths in the mining areas occurred due to chromite mine related diseases.

Under the caption "Cause of Mortality", deaths due to disease in the mining areas is reported to be 84.75%, compared to 79.17% in the control villages. Nowhere it is mentioned that the diseases are "chromite-mine related". On the other hand in the concluding chapter, the OVHA report states that in some of the areas diseases like malaria, TB, leprosy, gastroenteritis, paralysis etc. are quite common.

Potentially affected people: 2, 60,000.

The basis of this figure is not clear. It is more than 50% of the total population of Brahmani basin (approx.5.2 million). The ENVIS Newsletter published by the Centre for Environmental Studies (CES), Bhubaneswar (Vol.5, No.1, 2006 – one of the resource materials quoted in the Blacksmith report) mentions that 2.6 million people depend on Brahmani river for water and sustenance. If the Blacksmith report is to be accepted, it would mean that more than 50% of the total population of Brahmani basin and the entire population who depend on Brahmani water are affected by pollution in Sukinda, notwithstanding the fact that the concentration of total chromium has marginally exceeded the acceptable limits only at two locations (Bhuban & Dharmasala) during the last two years; The absurdity of the number of affected people given by Blacksmith is further clear from the following population figures(approx.); Villages in the Sukinda valley – 0.08 million, Sukinda Sub-Division – 0.15 million and Jajpur district – 1.63 million.

The Selection Process.

The selection process for the top 10 polluted places of the world, starts with the data base of sites **nominated** for Blacksmith consideration. After a preliminary screening, the nominations are reviewed in greater detail by **the** Technical Advisory Board (TAB). **It still remains heavily dependent on the experience and professional judgments of the TAB members**. Places are ranked on the basis of an impact score calculated using the following criteria.

Severity of Toxin, Scale of polluted source.

Human exposure pathway, Reliable evidence of health impact. Number of people potentially affected, level of exposure.

Number of children particularly at risk.

Additional high risk element (**TAB member discretion**).

Weights are attached to each of these factors in a 0-3 scale, **based on the advice of the TAB members.**

Several requests to provide the individual scores for each of the above factors for Sukinda valley, have not elicited any response.

The institute website states that for the biggest polluted areas, Blacksmith works with local partners, including environmental authorities, to identify large-scale interventions for potential funding by international agencies. The institutes enthusiasm to produce an exaggerated report on the severity of pollution of a place in a developing country is understandable.

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Table – 1
CHROMITE MINES IN SUKINDA VALLEY

Sl. No.	Mine	Year of commence ment	Present production (Million Tons/Annum)	Lease Area (Ha)		Remarks (**)
				Forest	Total (*)	
OPENCAST MINES						
1	Kamarda (B C Mohanty)	1968	0.00828	101.850	107.240 (95)	
2	Ostapal (FACOR)	1986	0.0739	68.424	72.843 (94)	
3	Tailangi (IDCOL)	2004	0.0128	20.882	65.683 (32)	
4	Chingudipal (IMFA)	1997	0.0040	26.620	26.620 (100)	No COB, Currently not in operation
5	Sukinda (IMFA)	1999	0.2550	0.000	116.760 (0)	No COB, No mine drainage water
6	Kaliapani (Balasore Alloys)	2000	0.1020	0.000	64.463 (0)	No mine drainage water
7	Kaliapani (Jindal)	2002	0.1002	24.241	89.000 (27)	
8	Saruabil (ML Mines)	1954	0.0500	224.633	246.858 (91)	
9	Southkaliapani (OMC)	1980	0.5000	416.499	552.457 (75)	
10	Kaliapani (OMC)	1967	0.0360	749.995	971.245 (77)	Semi mechanized, No COB
11	Sukrangi (OMC)	1980	0.0120	177.760	382.709 (46)	Manual, No COB, No mine drainage water
12	Sukinda (TISCO)	1960	0.9500	73.698	406.000 (18)	
UNDERGROUND						
13	Kathapal (FACOR)	1973	0.0300	113.312	113.312 (100)	No COB

* Figures in parenthesis are % of forest area
** Unless stated otherwise, all mines are mechanised and have COB plant

Table – 2
QUALITY OF MINE DRAINAGE WATER

Sl. No.	Mine	Date of Sampling	Cr.(VI) in mg/l.	
			ETP inlet	ETP outlet
1	Kamarda Chromite Mines (B.C.Mohanty & Sons Pvt. Ltd.)	26.08.05 02.06.06 12.03.07 19.09.07 16.11.07	0.109 0.020 1.235 0.220 0.223	BDL BDL 0.027 0.220 0.027
2	Ostapal Chromite Mines (FACOR)	24.08.05 16.11.07 12.12.07	0.460 1.020 1.108	BDL 1.025 0.011
3	Tailangi Chromite Mines (IDCOL)	31.05.06(I) 31.05.06(II) 10.03.07(I) 19.09.07(I) 19.09.07(II)	0.690 0.320 0.439 0.390 1.180	0.690 0.320 0.439 BDL BDL
4	Jindal Chromite Mines, Kaliapani.	25.08.04 04.02.05 24.08.05 20.09.07 12.12.07	0.226 1.259 1.092 1.200 0.864	0.113 BDL BDL 1.020 0.007
5	Chingudipal Chromite Mines (IMFA)	04.02.05 24.08.05 03.05.06	0.382 0.852 0.720	0.204 BDL BDL
6	Saruabil Chromite Mines (Mishrilal Mines Pvt. Ltd.)	26.12.03 25.08.05 19.09.07	0.220 0.299 0.380	0.119 BDL BDL
7	South Kaliapani Chromite Mines (OMC)	29.05.06(I) 29.05.06(II) 09.03.07 20.09.07 12.12.07	0.220 0.690 1.646 1.080 0.897	0.200 0.090 0.186 BDL 0.007
8	Kaliapani Chromite Mines (OMC)	23.08.05 30.05.06 27.10.06 16.11.07 12.12.07	- 0.170 0.214 0.180 0.186	0.108 BDL 0.080 0.056 0.014
9	Sukinda Chromite Mines (TISCO)	08.03.07 20.09.07 12.12.07	2.210 2.010 0.118	0.064 0.169 BDL 0.006
	STANDARD (max)			**0.100**

BDL = Below Detection Limit.

Table – 3

OVERBURDEN MANAGEMENT BY DIFFERENT MINES

Sl. No.	Mine	OB Management Status
1	Kamarda (B C Mohanty)	One active dump. One of the two old dumps are fully rehabilitated. Another partial.
2	Ostapal (FACOR)	One active dump. Management poor.
3	Tailangi (IDCOL)	One side of the slope in the active dump rehabilitated. Retaining wall in the old OB dump.
4	Chingudipal (IMFA)	One dump in the process of rehabilitation.
5.	Sukinda (IMFA)	Satisfactory. Garland drain with arrangement for treatment of the run off water.
6	Kaliapani (Balasore Alloys)	Not satisfactory.
7	Kaliapani (Jindal)	Two old dumps are partially rehabilitated.
8.	Suruabil (ML Mines)	Old dumps are properly rehabilitated with indigenous trees.
9.	South Kaliapani (OMC)	No rehabilitation.
10	Kaliapani (OMC)	Two sides of the active dump rehabilitated.
11	Sukrangi (OMC)	One active dump – No rehabilitation. Old dumps have been naturally stabilized due to growth of trees and shrubs.
12	Sukinda (TISCO)	There are a number of old OB dumps, which are suitably rehabilitated. The toes of the active dumps are stabilized with coir mats. Satisfactory.

Table – 4

AMBIENT AIR QUALITY IN SUKINDA VALLEY (Industrial Areas)
(April, 2004 to April, 2005)

All values in micrograms / cubic meter

Sl. No.	**Location**	**Season**	**SO_2**	**NO_x**	**SPM**	**RPM**	**Cr(VI)**	**Cr(III)**
1	Ostapal (FACOR) Quarry	Summer	BDL	9.7	267.0	91.0	0.014	0.066
		Monsoon	BDL	9.7	41.7	33.1	0.008	0.016
		Winter	BDL	9.9	273.9	102.8	0.009	0.080
2	Sukinda (IMFA) Office	Summer	BDL	8.7	188.0	83.3	-	-
		Monsoon	BDL	8.7	98.0	62.0	-	-
		Winter	BDL	13.8	153.5	82.0	0.037	0.047
3	Sukinda (IMFA) Quarry	Summer	BDL	24.9	1283.5	-	-	-
		Monsoon	BDL	24.7	101.5	39.0	-	-
		Winter	BDL	24.5	407.8	143.1	-	-
4	Kaliapani (Jindal) Mines Office	Summer	BDL	27.2	270.5	91.5	-	-
		Monsoon	BDL	27.1	45.0	30.1	0.007	0.014
		Winter	BDL	31.7	339.7	87.7	-	-
5	Kaliapani (Jindal) Quarry	Summer	BDL	16.3	1020.0	573.0	-	-
		Monsoon	BDL	16.3	81.3	62.0	0.020	0.028
		Winter	BDL	25.0	436.8	127.0	0.032	0.303
6	Saruabil Mines Quarry	Summer	BDL	38.4	141.0	48.0	0.001	0.059
		Monsoon	BDL	30.8	43.2	31.4	BDL	0.030
		Winter	BDL	37.3	177.0	71.3	0.116	0.174
7	Sukinda (TISCO) Stack Yard	Summer	BDL	13.1	48.9	27.6	0.005	0.046
		Monsoon	BDL	28.5	945.0	258.1	0.030	0.298
		Winter	BDL	28.0	1832.0	287.0	0.031	0.246
8	Sukinda (TISCO) Near COB	Summer	BDL	9.8	146.0	137.7	0.006	0.021
		Monsoon	BDL	8.2	31.2	19.3	0.068	0.110
		Winter	BDL	11.0	229.0	217.0	0.015	0.424
9	Kathapal (FACOR) Stack Yard	Summer	BDL	13.3	190.9	110.8	0.003	0.094
		Monsoon	BDL	6.0	80.0	60.0	0.012	0.062
		Winter	BDL	9.5	148.6	80.0	0.023	0.028
	STANDARD (max)		**120**	**120**	**500**	**150**		

Table – 5

AMBIENT AIR QUALITY IN SUKINDA VALLEY (Residential Areas)
(April, 2004 to April, 2005)

All values in micrograms / cubic meter

Sl. No.	Location	Season	SO_2	NO_x	SPM	RPM	Cr(VI)	Cr(III)
1	Ostapal (FACOR) Res. Quarters	Summer	BDL	49.0	55.0	46.0	0.008	0.081
		Monsoon	BDL	47.0	77.7	77.7	0.007	0.015
		Winter	BDL	49.0	87.0	67.0	-	-
2	Saruabil Office	Summer	BDL	13.2	158.0	72.0	0.010	0.018
		Monsoon	BDL	13.2	48.5	32.3	BDL	0.014
		Winter	BDL	10.2	320.5	-	0.019	0.187
3	Kaliapani (OMC) Crèche	Summer	BDL	57.0	313.0	124.0	0.004	0.060
		Monsoon	BDL	57.0	181.3	71.9	0.040	0.190
		Winter	BDL	59.7	268.3	-	-	-
4	Kaliapani (OMC) Pump House	Summer	BDL	25.2	170.0	87.0	-	-
		Monsoon	BDL	25.1	91.1	52.8	0.008	0.024
		Winter	BDL	28.7	58.4	44.9	BDL	0.019
5	Sukinda (TISCO) Near Laboratory	Summer	BDL	17.6	46.1	23.4	0.001	0.017
		Monsoon	BDL	27.9	106.7	98.1	0.025	0.064
		Winter	BDL	37.2	83.0	69.0	0.045	0.051
6	Kathapal (FACOR) Guest House	Summer	BDL	6.8	121.2	55.8	0.003	0.044
		Monsoon	BDL	6.8	74.1	39.3	0.003	0.041
		Winter	BDL	9.6	200.1	87.8	-	-
	STANDARD		**80**	**80**	**200**	**100**		

BDL : Below Detection Limit
SO2 : Sulphur Dioxide
NOx : Oxides of Nitrogen
SPM: Suspended Particulate Matter
RPM: Respirable Particulate Matter

Table - 6

SUSPENDED PARTICULATE MATTER (SPM) IN AMBIENT AIR

Sl. No.	Location	Date	SPM (micrograms/cubic meter
	INDUSTRIAL AREAS		
1	Kamarda – Office	29.09.06	294
	- Quarry	30.09.06	289
2	Ostapal (FACOR) – Mining area	31.05.06	171
3	Tailangi (IDCOL) – Mining area	31.05.06	247
4	Sukinda (IMFA) – Office	30.05.06	239
5	Kaliapani (BA) – Mining area	29.05.06	260
6	Saruabil – Magazine area	25.08.05	122
	- Mining area	31.05.06	272
7	South kaliapani (OMC) – Mining area	29.05.06	316
8	Kaliapani (OMC) – Mining area	30.05.05	208
9	Sukrangi (OMC) – Mining area	31.05.06	161
10	Sukinda (TISCO) – Stack Yard	07.03.07	600
	- Met Laboratory	07.03.07	282
	- COB Plant	08.03.07	564
11	Kathapal (FACOR) – Lease area	01.06.06	204
	STANDARD (max)		**500**
	RESIDENTIAL AREAS		
12	Ostapal (FACOR) - Dispensary	24.08.05	130
		08.03.07	230
13	Sukinda (IMFA) - Substation	30.05.06	402
14	Kaliapani (Jindal) - Dispensary	24.08.05	105
	STANDARD (max)		**200**

Table – 7

RANGE OF Cr(VI) CONCENTRATIONS IN DRINKING WATER SOURCES IN SUKINDA VALLEY

During the period from April, 2004 to April, 2005 (04 samples)

Sl.No.	Location.	Cr(VI) mg/l.
1	Bore well (TISCO)	0.030 – 0.040
2	Tube well (TISCO Colony)	BDL – 0.004
3	Bore well, Kathapal	0.002 – 0.003
4	Tube well, Kathapal	BDL – 0.016
5	Bore well, Ostapal	0.013 – 0.022
6	Tube well, Ostapal	0.008 – 0.019
7	Dug well, Ostapal	0.011 – 0.023
8	Bore well, Ostapal	0.021 – 0.044
9	Tube well, Suruabil	0.013 – 0.034
10	Bore well, Suruabil	0.021 – 0.035
11	Bore well, IMFA	0.003 – 0.035
12	Tube well, Kuchinda Banka	0.004 – 0.025
13	Tube well, Kuchinda Bank	0.041 – 0.06
14	Tube well, Maruabil	BDL – 0.015
15	Tube well, Maruabil	0.011 – 0.018
16	Dug well, Maruabil	0.009 – 0.023
17	Tube well, Bandhania	BDL – 0.004
18	Tube well, Bandhania	0.009 – 0.060
19	Tube well, Gurujang	0.010 – 0.450
20	Tube well, Kansa	0.008 – 0.024
21	Tube well, Birasal	BDL – 0.005
22	Tube well, Kamarsahi	BDL – 0.006
23	Tube well, Patna	0.003 – 0.027
24	Tube well, Patna	0.087 – 0.123
25	Tube well, Dhaboli	0.001 – 0.013
26	Tube well, Dhaboli	0.018 – 0.036
27	Tube well, Kaliapani	0.021 – 0.033
28	Tube well, South Kaliapani	BDL – 0.001
29	Dug well, Purunapani	0.009 – 0.017
30	Tube well, Purunapani	0.009 – 0.018
31	Tube well, Chingudipal	BDL – 0.008
32	Shallow Tube well, Suruabil	0.003 – 0.015
33	Tube well, Sukrangi	0.010 – 0.028
34	Tube well, Tailangi	0.003 – 0.025
35	Tube well, Rosai	BDL – 0.008
36	Tube well, Rangmatia	BDL – 0.011
37	Tube well, Baldiapal	0.003 – 0.009
38	Dug well, Pakatpani	0.005 – 0.009
39	Tube well, Balasore Alloys	0.002 – 0.004
40	Drinking water, OMC Office	0.001 – 0.004
41	Drinking water, TISCO	BDL – 0.006
	STANDARD (max)	**0.050**

BDL : Below Detection Limit

Table - 8

Cr (VI) IN WATER BODIES IN SUKINDA MINING AREA

Sl. No.	Source	Date of sampling	Cr.(VI) in mg/l
Mining Areas.			
1	Kmarda Chromite Mines - Tube well.	19.09.07 26.10.07 12.12.07	0.060 0.049 0.050
2.	Kaliapani Chromite Mines, Balasore Alloys – Tube well	12.12.07	0.031
Adjoining Villages.			
3	Tube well – Purunapani	20.09.07 26.10.07	0.060 0.046
4	Dug well – Purunapani	20.09.07 26.10.07	0.020 0.012
5	Pond – Purunapani	20.09.07 26.10.07	BDL 0.010
6	Tube well – Purunapani (IMFA)	26.10.07	0.005
7	Tube well – Gurujang UP School	26.10.07	0.007
8	Tube well – Gurujang (B. Mahanta)	26.10.07	0.010
9	Tube well – Patna Puruna Sahi	26.10.07	0.027
10	Tube well – Patna Majhi Sahi (I)	26.10.07 12.12.07	0.447 0.484
11	Tube well – Patna Majhi Sahi (II)	12.12.07	0.005
12	Stream – Patna Puruna Sahi	26.10.07	0.013
13	Tube well – Tailangi	19.09.07	BDL
14	Tube well – Saruabil	19.09.07 26.10.07 12.12.07	0.280 0.287 0.161
15	Tube well – Saruabil Mine Colony	12.12.07	0.049
16	Dug well – Saruabil Mine	19.09.07 26.10.07 12.12.07	0.040 0.038 0.041
17	Tube well – Kalarangiata	12.12.07	0.006
	STANDARD (max)		**0.050**

BDL = Below Detection Limit.

Table - 9

RANGE OF Cr (VI) CONCENTRATIONS IN DAMSALA RIVER

During the period from April, 2004 to April, 2005(04 samples)

Sl.No.	Location.	Cr(VI) mg/l.
1	Kansa (Upstream of all mining activity)	0.018 – 0.034
2	Before Kamarda Mines	0.010 – 0.023
3	Ostapal Mines	0.080 – 0.120
4	Near MIP	0.015 – 0.180
5	After MIP (Downstream of all mining activity)	0.016 – 0.034

Table - 10

Cr (VI) CONCENTRATION IN DAMSALA RIVER (2007)

Sl.No.	Location	Date of sampling	Cr(VI) in mg/l
1	Jargi sahi (Upstream of all mining activity)	19.09.07	BDL
2	D/S to Tailangi Mines	19.09.07	BDL
3	Damsala canal	20.09.07	0.020
4	Shallow well in the river bed (D/s to discharge from Tailangi Mines)	19.09.07	BDL
5	After MIP (D/s of all mining activity)	20.09.07	0.030
		12.12.07	0.024
	STANDARD (max)		**0.050**

BDL : Below Detection Limit