ECOLOGICAL, SOCIO-ECONOMIC & HEALTH IMPACT ASSESSMENT DUE TO ALUMINIUM SMELTERS – A CASE STUDY OF HINDALCO, IN ORISSA.

Prepared by –

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Our Perspective . . .

AIM OF THE STUDY

The aim of this study is to assess the impact of Aluminium Smelter Plant on the ecology of the study area and also to assess the impacts on the lives and livelihood of the people living in close proximity to the plant site.

OBJECTIVES

1. To assess the biodiversity richness of the study area.
2. To study the impact of emissions and effluents from the aluminium smelter plant on local ecology and available natural resources of the area.
3. To assess the extent of changes in land use patterns and the subsequent impact on the lives and livelihoods of the local indigenous people since the inception of the smelter.
4. To study the impact of emissions from Smelter plant on livelihood of local people.
5. To study the impact of emissions from Smelter plant on the health of local people living in villages and hamlets surrounding the plant area.

METHODOLOGY

1. Site Selection

2. Review of Literature
- Reports of Central Pollution Control Board
- Internet sites

3. Collection of secondary information about the study area
- Maps
- Toposheets
- Environmental Impact Assessment Reports of developments projects in the same study area

4. Preliminary field visit for gathering primary information about ecological impacts of Aluminium Smelter Plant in the study area
- Circulation of Questionnaire
- Interactions with Local People
- Field Visits to the selected site and its surrounding areas

5. Analysis of Physio-Chemical characteristics of water, soil and vegetation

6. Secondary field visit for gathering information about socio-economic and health impacts due to emissions from Smelter plant
- Interaction with local activists, NGOs and motivated individuals
- Sharing of findings
- Discussions and meetings with specific communities
- Interaction with Health Officials

7. Analysis and compilation of findings to fulfill all objectives

8. Report preparation

ALUMINIUM LIFE CYCLE

ALUMINIUM PRODUCTION

India is a vital player in global aluminum production. Although the construction of aluminum smelters is not a frequent occurrence, the establishment of such companies can have a significant local and regional impact, and some pollutants can be transported over considerable distances. The main chemical exposures of concern in this industry have been fluorides (as hydrogen fluoride gas and as particulate), PAHs, and the gases CO and SO_2. Various studies of existing facilities have demonstrated worker exposures in excess of the appropriate occupational exposure limits. As well, various physical factors (heat stress, EMFs, vibration) may be problematic.

ALUMINIUM PRODUCTION PROCESS

Aluminum is one of the most abundant elements on Earth (8%), after oxygen and silicon. Since it does not occur in its pure form in nature, but rather as various oxides, it must be extracted from ore and produced in specialized foundries known as smelters. Aluminum is currently one of the metals most widely used in the manufacture of various objects. Aluminum production is a very energy-intensive process that requires some 13 million watt-hours (13 340 kilowatt-hours) per tonne of metal produced. It also generates a great deal of residue; 2 tonnes of alumina obtained from 2.6 tonnes of bauxite are required to make 1 tonne of aluminum. It is 99% recyclable, which allows for substantial savings in terms of energy and raw materials.

MAIN STEPS IN PRIMARY ALUMINIUM PRODUCTION

- **Bauxite mining:** the mining of bauxite is the first step in aluminium production.
- **Production of alumina:** aluminium oxide, the raw material for primary aluminium production, is refined from bauxite.
- **Production of primary aluminium:** primary aluminium is produced by electrolysis.
- **Semi-fabrication:** this encompasses several industrial processes for the production of rolled products, extrusions, wire, tubes, forgings and castings.
- **Product manufacture:** aluminium is then processed into finished products.
- **Use phase:** the major applications of aluminium products are in transport, building and construction, packaging and engineering. In life cycle assessment the environmental aspects from the use phase of products are often most significant. For example, for a car the use phase accounts for about 90 % of total CO2 emissions. In this phase aluminium can bring substantial savings.
- **Recycling:** all collected aluminium products are recycled and used again in new products.

The steps in Aluminium production process are clearly depicted in **Annex – 1.**

Extraction of Aluminum from Bauxite: To produce primary aluminium metal, bauxite ore is mined, transported to processing plants called refineries, crushed, digested precipitated and calcined to produce alumina (Al_2O_3) powder in the Bayer Process which is used to extract alumina from bauxite. Bauxite contains hydrated alumina ($Al_2O_3 \cdot H_2O$) and various metal oxides (e.g., iron, titanium). Bauxite is mixed with caustic soda (NaOH) in an autoclave to form sodium aluminate ($Na_2O \cdot Al_2O_3$). This compound is heated at 1000^oC to obtain calcined aluminum oxide (Al_2O_3), or Alumina in powder form. On average, alumina refining consumes 75 kg of caustic soda and 48 kg of lime per metric tonne of alumina. Greenhouse gas emissions of 991 kg of CO_{2e} (carbon dioxide equivalents) per metric tonne of alumina are generated primarily from fuel consumption and from energy consumed in producing the lime and caustic soda ancillary materials.

Electrolysis: Aluminium Smelting is the step in which Primary aluminium is produced by the Hall-Heroult electrolytic process. Alumina is introduced into an electrolytic (reduction) cell or "pot" filled with two molten electrolytes: cryolite (Na_3AlF_6) and aluminum fluoride (AlF_3). The cell consists of a basin (the cathode) made up of heat-refractory material and a cathode lining, in which anodes made of carbon material are suspended. A current of 60 000-300 000 amperes is passed from the anode to the cathode at a temperature of 950^oC. At this temperature, the alumina is transformed into pure liquid aluminum by a reduction process (oxygen removal), according to the reaction: $2\ Al_2O_3 + 3\ C \rightarrow Al + 3\ CO_2$. Carbon (the 3 Cs) from the anodes is used in the reaction; as a result, the anodes become smaller and have to be replaced periodically. The additives (cryolite and aluminum fluoride) must also be replaced regularly because they evaporate and react with water vapour.

Casting of Metal Alloys and the Production of Anodes: Molten aluminum settles to the bottom of the electrolytic cells, from which it is siphoned off and cast into ingots of various shapes. To increase its malleability, weldability, and mechanical strength, aluminum may be combined with metals and other elements (manganese, magnesium, copper, zinc, and silicon) to create alloys.

Anode Production: Another important part of the overall process is the production of anodes, the positive electrodes through which electrical current is run in the electrolysis pot. Because anodes are consumed in the reaction, they must be replaced periodically. Anodes are made primarily of a mixture of coke (solid residue from petroleum distillation) and pitch (residue from the distillation of coal tar).

SMELTING TECHNOLOGY

ALUMINIUM SMELTING

The basis for all modern primary aluminium smelting plants is the Hall-Héroult Process, invented in 1886. Alumina is dissolved in an electrolytic bath of molten cryolite (sodium aluminium fluoride) within a large carbon or graphite lined steel container known as a "pot". An electric current is passed through the electrolyte at low voltage, but very high current, typically 150,000 amperes. The electric current flows between a carbon anode (positive), made of petroleum coke and pitch, and a cathode (negative), formed by the thick carbon or graphite lining of the pot. Molten aluminium is deposited at the bottom of the pot and is siphoned off periodically, taken to a holding furnace, often but not always blended to an alloy specification, cleaned and then generally cast. A typical aluminium smelter consists of around 300 pots. These will produce some 125,000 tonnes of aluminium annually. However, some of the latest generation of smelters are in the 350-400,000 tonne range. On average, around the world, it takes some 15.7 kWh of electricity to produce one kilogram of aluminium from alumina. Design and process improvements have progressively reduced this figure from about 21kWh in the 1950's.

SMELTER ENERGY USE

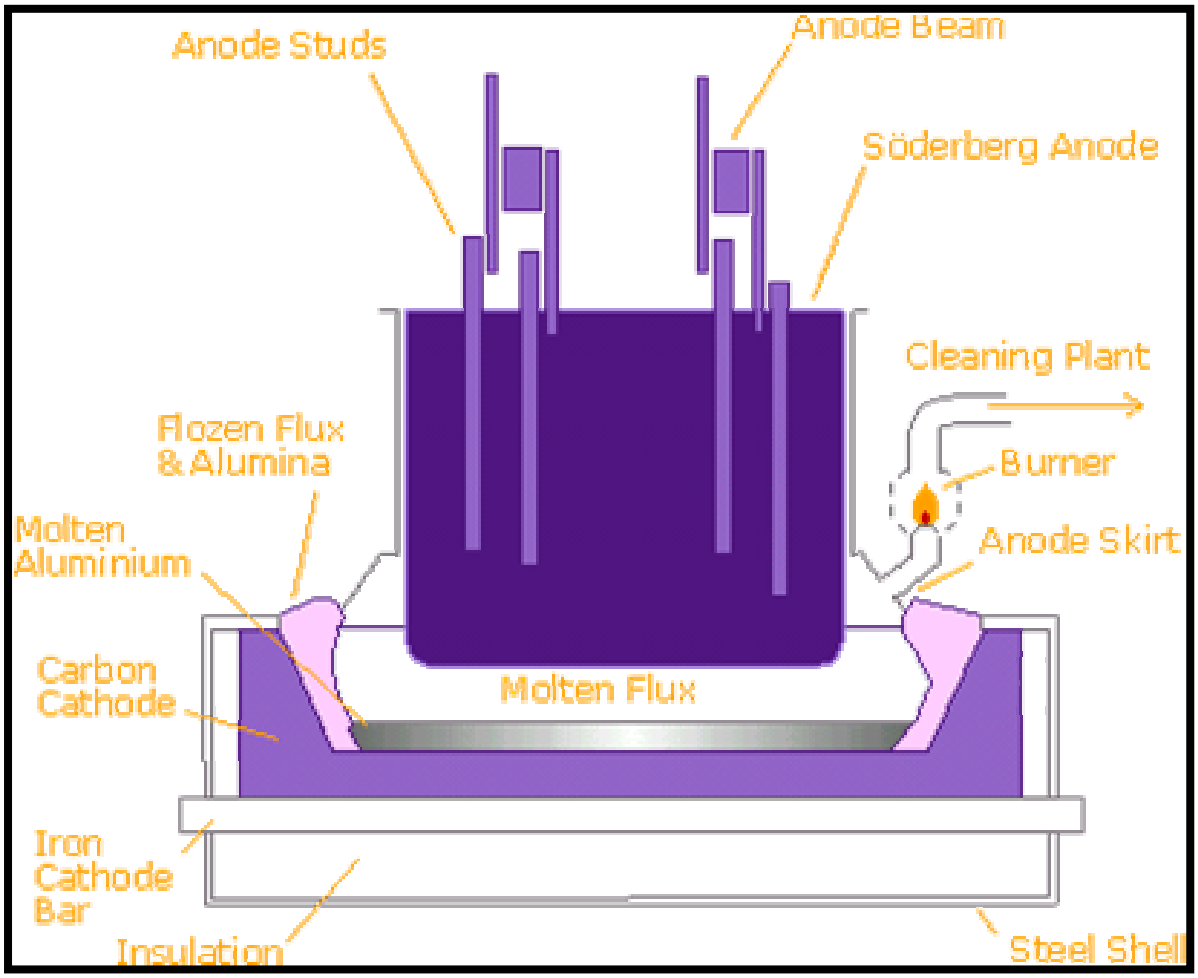
Aluminium is formed at about 900°C, but once formed has a melting point of only 660°C. In some smelters this spare heat is used to melt recycled metal. Recycled aluminium requires only 5 per cent of the energy required to make "new" aluminium. Blending recycled metal with new metal allows considerable energy savings, as well as the efficient use of process heat. There is no difference between primary and recycled aluminium in terms of quality or properties. Aluminium smelting is energy intensive, which is why the world's smelters are located in areas which have access to abundant power resources (hydro-electric, natural gas, coal or nuclear). Many locations are remote and the electricity is generated specifically for the aluminium plant.

The smelting process is continuous. A smelter cannot easily be stopped and restarted. If production is interrupted by a power supply failure of more than four hours, the metal in the pots will solidify, often requiring an expensive rebuilding process. From time to time individual pot linings reach the end of their useful life and the pots are then taken out of service and relined. Most smelters produce aluminium of 99.7% purity, which is acceptable for most applications. However, super purity aluminium (99.99%) is used for some special applications, typically those where high ductility or conductivity is required. The marginal difference in the purities of smelter grade aluminium and super purity aluminium results in significant changes in the properties of the metal.

SMELTING TECHNOLOGY TYPES

There are two main types of aluminium smelting technology - Söderberg and Pre-bake. The principal difference between the two is the type of anode used.

Söderberg Cell: Söderberg technology uses a continuous anode which is delivered to the cell (pot) in the form of a paste, and which bakes in the cell itself.



The Anode: As we have seen, the carbon anodes used in the Hall-Héroult process are consumed during electrolysis. Two designs exist for these anodes; "Söderberg" and "Pre-Bake". Pre-Bake anodes are made separately, using coke particles bonded with pitch and baked in an oven. Pre-bake anodes are consumed and must then be changed. Söderberg anodes on the other hand are baked by the heat from the electrolytic cell, they do not need changing but are "continuously consumed".

The Cathode: The cathode consists of a graphite shell embedded with steel bars to minimize current resistance. During operation the liquid aluminium itself begins to operate as the cathode, a feature

which can complicate cell design because of the inevitable magnetic effects of such large currents. Typically a cathode will last between 1000 and 2000 days before it needs replacing.

CELL CHEMISTRY AND PROCESSES

Alumina is reduced to aluminium metal in electrolytic cells known as pots, these are then organised into potlines.

The Potline: Pots are organised into "potlines" within an aluminium smelter. Modern potlines will tend to have pots arranged side-to-side and carry out almost all maintenance using overhead multipurpose cranes - several tasks have to be carried out regularly including replenishing alumina supplies, changing the anodes and removing the finished product, molten aluminium metal. The molten metal which is removed (or "tapped") from the cell is then transferred to a holding furnace prior to processing.

The Pot: A pot consists of two main parts:

1. A block of carbon which has been formed by baking a mixture of coke and pitch. This block serves as an anode (or positive electrode).
2. Under the anode is a large rectangular steel box lined with carbon made by baking a mixture of metallurgical coke and pitch. This lining is the cathode (or negative electrode).

Between the anode and the cathode is a space filled by electrolyte. This mixture must be heated to about 980°C, at which point it melts and the refined alumina is added, this then dissolves in the molten electrolyte.

Smelter Technology Types: This hot molten mixture is electrolyzed at a low voltage of 4-5 volts, but a high current of 50,000-280,000 amperes. This process reduces the aluminium ions to produce molten aluminium metal at the cathode, oxygen is produced at the graphite anode and reacts with the carbon to produce carbon dioxide.

$$\mathbf{2Al_2O_3 + 3C \text{ ---> } 4Al + 3CO_2}$$

However some of the metal, instead of being deposited at the bottom of the cell, is dissolved in the electrolyte and reoxidised by the CO_2 evolved at the anode:

$$\mathbf{2Al + 3CO_2 \text{ ---> } Al_2O_3 + 3CO}$$

This reaction can reduce the efficiency of the cell and increases the cell's carbon consumption.

The Electrolyte: The electrolyte used is cryolite (Na_3AlF_6) which is the best solvent for alumina. To improve the performance of the cells various other compounds are added including aluminium

fluoride and calcium fluoride (used to lower the electrolyte's freezing point). The electrolyte ensures that a physical separation is maintained between the liquid aluminium (at the cathode) and the carbon dioxide/carbon monoxide (at the anode).

THE ENVIRONMENTAL IMPACTS OF SMELTER PLANTS

SMELTER EMISSIONS

Research from all around the world showed that vegetation quickly recovered when fluoride emissions were reduced due to closure of smelter plants. There are two main types of fluoride emissions from any smelter plant:

- A mixture of the inorganic fluorides NaF, AlF_3 and Na_3AlF_6 (as particulates) and HF (as a gas);
- The organic Perfluorocarbons (CF_4 and C_2F_6) as gases.

❖ **Sulphur Dioxide**: Generated from the sulphur content at coal powered stations, and other parts of the aluminium production process - steam generation in alumina plants, ovens in anode plants and anode consumption in the pots. The remedy is to use low sulphur fuel and coke if available, and wet scrubbers to remove the particles from the air.

❖ **Carbon Dioxide**: Carbon dioxide is a feature of all metal processes which produce metal from ores containing oxides. The gas forms when the carbon in the anode combines with the oxygen in aluminium oxide during the smelting process. It is therefore an unavoidable by product of the aluminium smelting process.

❖ **Inorganic Fluorides**: These are compounds which have a local effect around a smelter (unlike PFCs which do not have any local effects but a global effect as a Greenhouse Gas).

❖ **Perfluorocarbons (PFCs) - Tetrafluoromethane (CF_4) and Hexafluoroethane (C_2F_6)**: These gases are chemically inert but have high global warming potential, they are produced in very small quantities during "anode effects" when the alumina concentration in the cryolite bath is reduced. The carbon anode then reacts directly with the fluoride in the electrolyte.

The process for production of aluminum and pollution outputs is clearly depicted in **Annex – 2.** The various pollutants released from the Aluminum Smelter plants and their impacts on the surrounding ecology and human health is elaborately described below:

ATMOSPHERIC POLLUTANTS AND THEIR POSSIBLE HEALTH EFFECTS

The extraction of alumina from bauxite, the electrolysis process, the casting of metal, and the production of anodes generally produce several types of atmospheric pollutants: particulates, SO_2, CO_2, fluorinated compounds, and PAHs.

Particulates: Eighty percent of particulates are generated by the electrolysis process and consist mainly of fluorinated particulates. Although today's aluminum smelters are equipped with air cleaning systems, some pollutants escape through roof vents. There has been a very serious and progressive effort to establish more particle size selective occupational exposure limits through a three tier system:

The first tier is known as ***inhalable or inspirable particulates***; this replaces total dust. Inhalable particulates are less than 100 mm in diameter. Inhalable particulates deposit throughout the respiratory system depending upon their aerodynamic size. The largest particles in the 25 to 100 mm size range deposit in the nasophyranx. Particles in the 10 to 25 mm range deposit in lung's airways, while the smallest particles deposit in the alveoli. The second tier is known as "***thoracic" particulates***. This fraction is less than 2.5 mm in diameter, and the particles deposit in the airway and gas exchange regions of the lung. The third tier is known as ***"respirable" particulates***. These particles are less than 1.0 mm in diameter and mostly deposit in the gas exchange region of the lungs.

Silica: Furnaces are commonly featured in many, and perhaps most workplaces in the aluminium industry. Furnaces are used in alumina calcination, anode baking, casting and numerous heat treat processes. The furnaces are constructed and insulated with various refractories. At one time, much of our occupational health focus was on the use of asbestos, and the exposures associated with furnace overhauls. Later, the focus was on the use of refractory ceramic fibres, and other synthetic mineral fibres. Asbestos and mineral fibres remain on our occupational health agendas, while there has been an increased focus in recent years on exposures to the crystalline phases of silica. Many refractories contain significant percentages of both quartz and cristobalite. IARC has recently classified crystalline silica as a group 1A carcinogen.

Sulphur Dioxide: SO_2 emissions are generated mainly (98%) by electrolysis and are usually not collected or scrubbed. SO_2 can have adverse effects on plants, mostly because it is converted to sulphuric acid by contact with moisture. Conifers, lichens, and mosses are among the plants most sensitive to SO_2, which is one of the principal pollutants contributing to acid rain.

Carbon Dioxide: Most CO_2 emissions are produced in the electrolysis process and in the production of anodes. The amount of CO_2 emissions is quite large: a company producing 370 000 tonnes/year of aluminum can release as much as 600 000 tonnes/year of this greenhouse gas into the environment, where it can have various health impacts within the context of global warming.

Fluorinated Compounds: Fluorinated compounds are usually released as hydrogen fluoride (HF) associated with particulates. Ninety-nine percent of these emissions are produced by electrolytic cells. Dust control systems, however, do prevent some of these emissions from entering the environment. Fluorine is a highly reactive, very toxic halogen that is absorbed by plants that are very sensitive to it (particularly conifers). Animals, including livestock that feed on contaminated plants can develop osteoporosis or even osteosclerosis. The permissible limit for fluorine in forage is usually of the order of 40 ppm. Exposure to HF can lead to eye and skin irritations (> 900 $\mu g/m^3$), irritations of the respiratory tract (> 2100 $\mu g/m^3$), dental fluorosis, and osteoporosis (>1780 $\mu g/m^3$ – 8 h/day of continuous exposure). Aluminum plant workers are the most exposed, since ambient concentrations in pot lines can sometimes reach 1500 $\mu g/m^3$.

PFC Emissions: PFCs are not generated during normal smelting operating conditions. They are only produced during brief upset conditions known as "anode effects". These conditions occur when the level of the dissolved aluminium oxide (the raw material for primary aluminium) in the cell drops too low and the electrolytic bath itself begins to undergo electrolysis. Measures to reduce the frequency and duration of anode effects not only reduce greenhouse gas emissions but they also benefit the producer by improving energy and process efficiency.

Polycyclic Aromatic Hydrocarbons: PAHs are mostly produced by the combustion of various carbon-based materials. Several PAHs are considered carcinogens or potential carcinogens. Workers are most at risk, and bladder cancer has been associated with PAH exposure. Public health risks must be assessed in terms of anticipated or measured ambient concentrations. Benzo[a]pyrene is a typical PAH, and its ambient air concentration should not exceed 0.9 ng/m^3. Concentrations usually found in the environment outside a new aluminum smelter plant vary from 0.05 to 0.1 ng/m^3; they can be much higher, however, near old aluminum smelters (2-35 ng/m^3).

Ozone: Ozone exposures associated with aluminum production can be a significant occupational hygiene issue for three reasons:

• Ozone exposures can easily exceed occupational exposure limits. The ACGIH has proposed three limits for ozone, with values ranging from 0.05 to 0.1 ppm depending upon the physical workload.

• Ozone exposures are difficult to measure. The standard method has been liquid impingers, but the use of impingers in the workplace is generally impractical. The standard OSHA method in the US involves the use of nitrite impregnated glass fibre filters. Ozone converts the nitrite to nitrate. The method has not been fully validated and there is some question about its accuracy under conditions of low humidity. Finally, some instrument manufacturers now market electrochemical sensors for monitoring ozone exposures, but again adequate validation information on accuracy, precision and interference's are not available.

• A third reason why ozone is a significant issue is the difficulty in controlling ozone exposures. Unlike welding fumes, ozone is generated by the effect of ultraviolet light on oxygen. Hence ozone is generated at some distances from the welding arc thereby reducing the effectiveness of conventional local exhaust ventilation.

LIQUID EFFLUENTS AND THEIR POSSIBLE HEALTH EFFECTS

There are three main sources of liquid effluents in aluminum production:

1. Process water, used mainly for cooling during metal casting and in the production of anodes. Process water contains small quantities of organic matter, aluminum, fluorides, suspended solids, oils, industrial greases, and PAHs;
2. Wastewater from restroom, canteens, and laboratory facilities, containing suspended solids and organic matter; and
3. Drainage water, which consists primarily of rainfall (or snowmelt) runoff from buildings and the land around them.

In modern aluminum smelters, these waters are normally collected and sent to a water treatment centre where most pollutants are eliminated. Suspended solids and organic matter discharges are also reduced. In a modern, environmentally sound aluminum smelter, therefore, liquid effluents have a limited impact on health and the environment. Suspended solids, organic matter, and industrial greases and oils, however, quite apart from their aesthetic impact, have a negative impact on aquatic life.

Fluorides: Fluorides can accumulate in aquatic organisms and can work their way into the water table. Too much fluorine in water can lead to dental fluorosis during the critical tooth development period in children less than six years of age and, on a longer-term basis, to osteoporosis. Daily intakes of fluoride by means of food, toothpaste, and mouthwash (17-78 µg/kg of adult body weight), however, are generally higher than all other forms of absorption.

Aluminum: Aluminum is toxic to fish and aquatic insects in concentrations exceeding 1 mg/L. This metal may also constitute a slight risk to public health. It has a low acute toxicity (1 µg/kg body weight) and is neither mutagenic nor carcinogenic. When ingested in excessive amounts, aluminum (or its salts) causes nausea, vomiting, diarrhea, and oral ulceration. Aluminum has been shown to have neurotoxic effects in some animals, but no causal link has been established between aluminum intake and Alzheimer's disease. No recommendations exist with respect to drinking water, and alum (a major source of aluminum) is almost universally used in water treatment processes (for the flocculation of suspended solids); a maximum concentration of 0.2 mg/L of aluminum would be desirable in water.

Polycyclic Aromatic Hydrocarbons: PAHs can be released directly into water (wet scrubbing of electrolytic gases, cell waste, spent anodes, maintenance waste, etc.) or be atmospheric in origin. Aluminum smelters constitute a significant potential source of PAH water pollution, the health impact of which must be given due consideration.

SOLID WASTE RESIDUES AND THEIR POSSIBLE HEALTH EFFECTS

The principal forms of solid waste residues generated by aluminum production are:

1. Red mud, produced when alumina is extracted from bauxite;
2. Spent potlining generated when electrolytic cells are refurbished; and
3. Dross from aluminum casting.

Added to these residues are various wastes (spent anodes, aluminum pellets, domestic waste, etc.) that present a limited risk to public health.

Red Mud: Bauxite residue (also known as red mud) is a by-product of the Bayer Process. The amount of residue generated, per tonne of alumina produced, varies greatly depending on the type of bauxite used, from 0.3 tonnes for high grade bauxite to 2.5 tonnes for very low grade. Its chemical and physical properties depend primarily on the bauxite used and, to a lesser extent, on the manner in which it is processed. Bauxite is composed principally of the monohydrate and trihydrate forms of alumina in varying proportions. Major impurities are the oxides of iron, silica and titanium, while such elements as zinc, phosphorous, nickel and vanadium are found in trace amounts. The residue from the alumina production contains the impurities which are not dissolved to any significant degree, plus alumina that is not extracted in the process. For various reasons, most alumina producers add lime at some point in the process and the lime forms a number of compounds that end up with the bauxite residue.

CHEMICAL COMPOSITION OF BAUXITE RESIDUES

Fe_2O_3	(30 - 60%);
Al_2O_3	(10 - 20%);
SiO_2	(3 - 50%);
Na_2O	(2 - 10%);
CaO	(2 - 8%);
TiO_2	(Trace - 10%)

Apart from the alkalinity that is imparted by liquors in the process, the residue is chemically stable and non-toxic. Bauxite residue is most often disposed of on land using one of a variety of methods. Once such land has been decommissioned is can be used to grow crops or other vegetation. Alternatively the land can be used for building, depending upon the moisture of the residue. Bauxite residue has also been used to reclaim land at the seashore with no adverse environmental effects.

Spent Pot lining: The refractory material in the electrolytic cells, referred to as pot lining, must be replaced every 5-8 years. The principal solid waste from the electrolysis process is spent pot lining. A major smelting plant can generate as much as 10,000 tones of spent pot lining annually.

Because of its cyanide and fluoride content, spent pot lining is considered hazardous waste and must be stored safely. If it is properly stored or recycled, it poses little risk to public health; however, its toxicity must be taken into account in the event of an industrial accident or a natural disaster (e.g., fires and floods). When exposed to water, acids, or alkaline substances, pot lining can emit toxic, flammable, and potentially explosive gases (fluorides, ammonia, hydrogen cyanide, sulphur oxides, hydrogen, and acetylene).

Symptoms of toxicity may arise following contact with the skin or eyes or following inhalation. Acute effects include burns to the skin and severe irritation of the respiratory tract. Spent pot lining should not be transported in a warm or damp state, and care should be taken to avoid all skin contact. The risk to public health is minimized if spent pot lining remains on the aluminum plant site. Plant workers receive the greatest amount of exposure. Where landfill is used, precautions are taken to ensure that the waste material cannot leach out of the site through rainfall. This is normally done by lining the landfill site and covering it with an impermeable liner. Groundwater and soil are continually monitored for contamination.

Dross: The residue produced during ingot casting is called dross. It contains 50% aluminum, and it can react vigorously with water or moisture to produce highly toxic fluorinated gases. In today's modern aluminum plants, dross is usually recycled; however, it must be stored in argon containers to reduce its reactivity during transportation.

As is the case with spent pot lining, dross can release toxic, flammable, and potentially explosive gases (fluorides, ammonia, hydrogen, and acetylene) when exposed to water, acids, or alkaline substances. Exposure to vapors can lead to acute reactions, such as eye, skin, and respiratory tract irritations and bronchial spasms and dyspnea.

Dross and its vapors must not come into contact with the skin or eyes. Dross should be stored dry and protected from bad weather. The main risk to public health would stem from accidental spillage in transportation; under normal circumstances, plant workers are the group most highly exposed to dross.

NUISANCES AND TECHNOLOGICAL RISK

Noise: As with many industrial activities, noise is one of the possible nuisances that can have an impact on public health. Noise can be produced by fixed sources (e.g., ventilators, compressors, generators, and electrical transmission lines) or mobile sources (e.g., trucks and trains). Without mitigation measures, an aluminum smelter can produce an average noise level (L_{eq} 1 hour) of 55 dB at a distance of 2 km and 45 dB (L_{eq} 1 hour) at more than 3 km. With noise mitigation measures, however, intensity is reduced to 35 dB at 2 km and 25 dB at 4 km.

Aluminum smelter plants are extremely large and aesthetically unappealing facilities. Their related infrastructure (high-voltage power lines, railway lines, and roads) can also disrupt the agricultural, forest, and urban environments. A fairly broad buffer zone must be planned around a plant site, in anticipation of fluorine and PAH fallout. Aluminum plants and their infrastructure can affect local quality of life and lower residential property values. Notwithstanding the economic benefits of aluminum plants (jobs, commercial businesses, etc.), their negative social impacts should not be overlooked.

Technological risk: The potential for industrial accidents is generally confined to the plant itself and poses little risk to public health. Possible events that must be considered public health risks are:

- A break in a gas or oil pipeline resulting in an explosion, which can cause injuries up to a distance of 100 m; and
- An ammonia cloud caused by dross or pot lining coming into contact with water (effects may extend as far as about 200 m from the point of incident).

HEALTH IMPACTS OF ALUMINIUM SMELTER PLANTS

Aluminium is the third most common element found in the earth's crust, after oxygen and silicon. It has been estimated that the average human body contains, at most, 35 mg of aluminium, of which approximately 50% is in the lungs, and most of the remainder is in the skeleton. There is no known biological role for aluminium - it does not appear to be an essential trace element - and the body has highly effective barriers to exclude aluminium and similar metals. Only a minimal fraction of aluminium in the diet is taken up from the gut and in healthy individuals the kidneys quickly excrete most of this absorbed aluminium. The brain is vulnerable to many substances, including aluminium, but there is a "blood-brain barrier" which prevents the aluminium in blood from readily entering this organ. When aluminium blood levels are high, bones appear to act as a "sink", taking up aluminium and releasing it slowly over a long period. The question that is uppermost in my mind is whether -

THERE IS ANY SCIENTIFIC EVIDENCE THAT OCCUPATIONAL EXPOSURE TO ALUMINUM CONSTITUTES A HEALTH RISK TO WORKERS ?

We have reviewed the medical literature on this subject and consulted numerous experts in order to investigate a broad range of possible outcomes of aluminum exposure, including Alzheimer's disease. We have reviewed epidemiological surveys of aluminum smelter plants and also considered reports of clinical findings, research on animals, anecdotal evidence from workers, employers and doctors.

Aluminium and Health

Aluminum is a naturally occurring substance and is the most common metal in the earth's crust. Daily exposure is unavoidable by ingestion through food and water and by inhalation from the atmosphere. Aluminum has no known nutritional benefit. Normal daily intake in adults is estimated to be about 9 to 14 milligrams but may be much higher depending on diet and intake of aluminum-containing medication such as antacids. Normal total body aluminum content is in the range of 30 to 40 milligrams. It is important to distinguish between the amount of aluminum to which people are exposed and the amount of aluminum which is not eliminated but is absorbed by the body and accumulated in tissue.In healthy people, the "blood-brain barrier" almost completely prevents aluminum from accumulating in the brain.

All the medical experts consulted by us have advised that it is important to distinguish between the amount of aluminum to which people are exposed and the amount of aluminum which is not eliminated but is absorbed by the body and accumulated in tissues. The skin, lungs and gastrointestinal tract "serve as almost complete barriers to aluminum absorption." In healthy people, the "blood-brain barrier" almost completely prevents aluminum from accumulating in the brain. Some researchers believe that Alzheimer's Disease involves a defect in the blood-brain barrier. The highest accumulation occurs in the lungs and bone. Although the concentration of aluminum is highest in lung tissue, 50% of body burden occurs in bone because bone mass is so much greater than lung mass. Accumulation in the lungs and brain appears to increase with age.

OCCUPATIONAL SURVEYS

Studies of overall death rates in aluminum workers found either no increase or lower rates than expected. A table of Health Impacts due to Aluminium Industry is provided in **Annex – 3.**

Mortality

Studies of overall death rates in aluminum workers found either no increase or lower rates than expected.

Cancer

A review of the literature concludes that, except perhaps in cases of extremely high exposure, aluminum is not carcinogenic. Two surveys of mortality in aluminum reduction plant workers found increases in cancer rates one of which attributed this to coal tar pitch volatiles. Two epidemiological studies found evidence of increased rates of bladder cancer in workers in the aluminum industry. One of those researchers related the increase to polycyclic aromatic hydrocarbon exposure and the other related it to exposure to coal tar pitch volatiles.

Respiratory effects

For a few years there were reports of lung fibrosis having occurred in workers who produced fine aluminum powder in the pyrotechnics industry. The cause of those diseases is now attributed to the mineral oil coating which was applied to the aluminum particles. In those cases which did not involve coated aluminum particles, the cause of the fibrosis has been attributed to the workers' exposure to silica, rather than to their exposure to aluminum. However, lung fibrosis was attributed to the worker's heavy aluminum dust exposure.

Through our surveys we found increased rates of respiratory disease in aluminum workers. In one of these, coal tar pitch volatiles were considered the cause. Slight impairment in lung function has been observed, as has bronchitis, which was considered related to ozone exposure. We also found increased rates of asthma in aluminum smelter plant workers. There are reports of reduced lung function proportionate to workers' exposure to mixed dusts including aluminum. Nine workers in an abrasives plant with "prolonged heavy" exposure to aluminum oxide dust were found to have pulmonary fibrosis. The cause was determined to most likely be exposure to aluminum oxide, but possibly exposure to mixed dusts.

Alzheimer's Disease

There is one study report on Alzheimer's Disease in which, this disease is found to be occurring in one man who had worked for thirty years as an aluminum refiner in Japan. The authors compared his brain aluminum content to that of another Alzheimer's Disease victim and a victim of subacute

sclerosing panencephalitis ("SSP"), neither of whom had occupational exposure to aluminum. They found aluminum accumulation in the aluminum refiner but not in either of the non-occupationally exposed victims. The authors concluded that aluminum does not necessarily contribute to the formation of Alzheimer's lesions, but it accumulates as a secondary effect in Alzheimer's victims who have had occupational exposure.

Aluminum may accumulate in the brains of Alzheimer's Disease victims because the disease causes a defect in the normally protective blood-brain barrier which makes the brain a willing host for aluminum deposition. Researchers do not agree about whether aluminum is one of the factors which causes Alzheimer's Disease or whether its accumulation in the brain is a secondary effect of the disease. Aluminum may accumulate in the brain because the disease causes a defect in the normally protective blood-brain barrier which makes the brain a willing host for aluminum deposition. Some studies suggest a relationship between the incidence of Alzheimer's Disease and aluminum levels in local drinking water but other researchers consider that suggestion "premature" and "unwise." Another study did not find such a relationship. While the cause of Alzheimer's Disease remains unknown, aging, head injury, family history, genetic factors and thyroid disease have been linked.

Aluminum and Encephalopathy

Dialysis Encephopathy Syndrome (DES) in kidney patients is believed to be caused by extremely high aluminum exposure. It is known that aluminum in very large amounts can be neurotoxic. "Dialysis Encephalopathy Syndrome" (which is also called "DES" or "dialysis dementia") is a usually fatal condition which has occurred in some of the kidney dialysis patients whose blood levels rose to 7400 nmol/litre or above when their dialysis fluid contained large amounts of aluminum. DES has now been largely eliminated because current treatment protocol requires removal of aluminum from dialysis fluid.

Not all of the dialysis patients who receive the same high doses of aluminum develop DES, nor does it usually occur in adults who take large oral doses of aluminum-containing antacids but are not undergoing dialysis. There is no evidence that patients with DES will go on to develop Alzheimer's Disease, possibly because they do not live long enough to do so. Although brain aluminum content is greatly elevated in DES patients, they do not develop the neurofibrillary degeneration which is a marker of Alzheimer's Disease. In animal studies, there is evidence of encephalopathy being induced in cats whose brains were directly injected with aluminum chloride or lactate and in rabbits after central nervous system exposure to aluminum. However, the changes in the brains of humans and animals with aluminum-induced encephalopathy are not identical the changes which occur in Alzheimer's Disease.

Others

Aluminum welding fumes have been found to be the cause of upper respiratory and eye irritations

ECOLOGICAL, SOCIO-ECONOMIC & HEALTH IMPACT ASSESSMENT DUE TO ALUMINIUM SMELTERS – A CASE STUDY OF HINDALCO SMELTER PLANT IN ORISSA

INTRODUCTION TO THE STUDY AREA

HINDALCO industries which was previously known as INDAL has been in operation with 24,000 TPA of aluminum smelting capacity since 1961. Presently the unit is engaged in production of primary aluminum (purity 99.6%) and is presently operating at 65000 MT capacities. This industry is located in Hirakud town, which is about 12 KM away from Sambalpur town. This industry is well connected with the National Highway. This industrial site is very close to the famous Hirakud earthen dam.

The existing plant has the following infrastructure:

Smelter plant: Hirakud smelter presently has a capacity of 30 KTA of aluminum metal. The present smelter has five pot rows which accommodate a total of 216 pots. Four pot rooms are 284 meter long and 11.25 meter wide accommodating 43 pots each. The fifth pot room is 160 meter long and 17.54 meter wide and has 44pots. These pots are electrically composed in series and carry a pot line.

Carbon paste plant: Carbon paste is requirement for captive consumption for feeder to the anodes matching carbon blocks and for sale to third party like ferroalloy manufacturing units. For this purposes, calcinated petroleum coke is being used with coal tar pitch as binder. Calcinated petroleum coke is crushed and grinded in ball mill and stored in separate units.

Captive power plant: The smelter plant has its own captive power plant located in the plant area. It gets coal form its captive coal mine located at Talabira-1 project.

RATIONALE FOR SELECTION OF THIS SITE FOR OUR STUDY

M/S HINDALCO has been accredited with the prestigious ISO14001 for its so called exemplary work in practicing environmental management in the plant. However, our visit to the site has helped us to ascertain the extent to which such environmental management programmes were being practiced by HINDALCO. There are a few examples on the basis of which we cannot accept the authenticity of the grounds for awarding accreditation to the smelter plant. These instances include:

1. Inadequate green cover around the plant site,
2. Absence of a proper polythene lining inside the hazardous waste dumping pond,
3. Haphazardly thrown pot lining all around the plant site which has had deleterious impacts on the agricultural productivity,
4. Deliberate deactivation of the ESP at nights as a result of which there is immense dust pollution during nights and early mornings.
5. Periodical gas leaks resulting in mass destruction of crops and vegetation have also played a key role in prompting us to take up this case.

In response to all these aforesaid reasons, we decided to take up this area for our study and conduct detailed Impact Assessment Studies from the ecological, socio-economic and health perspective.

SURVEY RESULTS OF VILLAGE – 1

1. . **Name of the village and distance from the industry:** Larbanga, 4 KM away from the industry and this village is some 200 meters away from the fly ash disposal site.
2. **Total population**: 1913 (male-937, female-976)
3. **SC & ST population**: 191(SC), 1315(ST).
4. **Forest area**: Nil.
5. **Population affected due to industry**: Some 199 acre of government land has been acquired by the industry for dumping its fly ash. Although this land belongs to the government land, the villagers previously used it as their grazing land. But right now due to disposal of fly ash in this site, the nearby vegetation has been degraded. The fly ash from this disposal site is causing a lot problem in summer days in the nearby villages as it settles on the surface of the plant thus affecting plantation and vegetation. Similarly, the villagers are facing lot of dust pollution during summer days due to dispersion of ash particles under the influence of wind.
6. **Drinking water sources and present problem due to industrial activity**: Five tube wells are found in this village. However during summer days the water levels receded drastically. The villagers have to depend upon the wells which is not fit for consumption.
7. **Medical facilities in the villages**: No the village has no such facility. The villagers have to depend upon the Hirakdud NAC hospital for any health related problem and in case of emergency they depend upon the Burla Medical college hospital which is some 20 KM away from here.
    (a) **Nearer health centre**: Hirakud NAC hospital.
    (b) **Number of doctors visiting the villages**: NIL
8. **Diseases usually reported**: cough, ARI (acute respiratory problem), dermatitis and other skin problem, Diarrhea, malaria, joint pain and gastroenteritis. Maximum of the villagers complains of eye allergy due to fly ash particles in the air, respiratory related diseases.
9. **Longevity of the villagers**: 60(previous it was 75+)
10. **What do villagers do when family members are sick?** The villagers are more dependent upon the Hirakud NAC hospital for their health related problem. However some villagers use various type of Herbal medicine, homeopathic medicines available in the nearer area.
11. **Which medicine do they prefer?** Villagers are dependent on the medicines supplied by the quacks as doctors do not visit the area. It is found that most of the villagers prefer allopathic medicine.
12. **Take bath every day**: Yes, but have to go to some 1-2 km for bathing purposes.
13. **Washes clothes everyday**: No the villagers wash the clothes in the interval of 7-10 day.
14. **What type of container they use for keeping water**: Mud pot, some uses plastic container such as large drum, bucket.

15. **Clean the drain regularly**- No drainage facility is available in the village.
16. **Put bleaching powder in the well**: Rarely.
17. **Percentage of people who live and work in the city**: no data in found in this regard.
18. **Number of people with seasonal allergies that interfere with daily activities**: Most of the villagers of the villager especially children and women suffers from allergy like cough and cold. During survey it was found that gastro-intestinal diseases is commonly found in case of children, and elder person due to taking up contaminated water. Similarly during summer days, the temperature hovers around 50^0 c - 55^0c due to which the villagers get affected due to sunstroke in summer days. During study it was found out that maximum number of the peoples are being affected with respiratory, eye and skin allergy.
19. **Number of death's per year due to HIV/AIDS:** No.
20. **Literacy rate**: 47.5%(male 62.8 and female 32.9)
21. **Access to potable water per capita:** Although the village has 5 bore wells but all these get dried during summer days. Peoples are less aware about hygienic water so more peoples are being affected due to various types of water borne diseases.
22. **Average distance traveled to retrieve safe drinking water**: 500 meter.
23. **Impact of the industrial activity on common peoples**: This village comprises various groups of people. But maximum numbers of people of this village are fisherman and they earns rupees by fishing in the Hirakud reservoir. But due to huge withdrawal of water by various industries, the water level in the reservoir is receding in a fast rate especially during summer days due to which the production of fishes is getting lower. Similarly some peoples of this village also depends upon agriculture, but the emission of large amount of dust from the captive power plant of HINDALCO is causing a lot of damage to the agriculture especially the vegetables and fruits as these dust settles upon the plant forming a thin layer on the surface of the leaf thus affecting its productivity.
24. **Basic livelihoods of the villagers and affect of it due to industrial activity:** No person from this village has got employment in HINDALCO. Rather the lively hood of some 40 families (milk man) has been affected as the pasture land that the villages used for grazing of their cattle has been given lease to the HINDALCO Company and they have been denied to permit this area. Similarly the dusts from the disposal site and from carrying trucks loaded with fly ash are causing a lot of damage to the vegetation in this village.
25. **What do villagers think of the future?** The villagers are in the view that they have not got any benefit from the company rather they have loose some of their precious land due to dumping of fly ash. Some influential villagers having well economic condition has definitely benefited by getting some contractor jobs for the company. But the common peoples have not got any benefit in this regard. The leach out from the disposal site has affected the ground water thus making the water unfit for consumption. The top soil of the field in this area has lost its productivity due to erosion from the disposal site and affecting the productivity of the soil.

SURVEY RESULTS OF VILLAGE – 2

1. **Name of the village and distance from the industry:** Nuajamuda, 500M away from the industry and this village has been partially affected due to the leakage of chlorine gas from the HINDALCO industry in 2003.
2. **Total population**:
3. **SC & ST population**:
4. **Forest area**: Nil.
5. **Population affected due to industry**:

   As this village comes under the core area of the industry i.e. some 500 meter distance, it has been largely affected due to the pollution emission from the industry especially from the smelting unit and from the captive power plant. The farmers are the most sufferers as their vegetable and paddy production rate has significantly reduced during the last 4- 5 years. Even during 2003, a large portion of paddy got damaged due to leakage of the chlorine gas. This problem is aggravated in rainy season when the pollutants emitted from the plant can not get dispersed and deposited in this area along with the rain water.

6. **Drinking water sources and present problem due to industrial activity**:

   Presently there are 3 tube wells found in this village. Except this a number of wells are also found in this village. But the problems of drinking water start in summer days when the water tables recedes very firstly. Another major problem of drinking water is the settling of fly dusts emitting from HINDALCO chimney which settles as a layer on the surface of well so the villagers complain that this water polluted with fly ash dust is causing various types of diseases.

7. **Medical facilities in the villages**: No. the villagers have to depend upon the Hirakdud NAC hospital for any health related problem and in case of emergency they depend upon the Burla medical college hospital which is some 20 KM away from here.

   (a) **Nearer health centre**: Hirakud NAC hospital.

   (b) **Number of doctors visiting the villages**: NIL.

8. **Diseases usually reported**:

   With interacting with the villagers it was found out that respiratory related disease is commonly found in this village as the power plant chimney is very near to this village. The wind rose diagrams of this area shows that this village comes under route of wind direction, so the tiny dusts emitting from the chimney settles in this village. Similarly the dust is causing various types of skin diseases like itching problem, small ulcers in the skin. Some people also complain about arthritis and this problem is found in case of old person and children. In case of older peoples, the bone related problem is found to be

high and it may be concluded that , the fluoride emissions from the smelter plant is causing fluoride problem in this area.

9. **Longevity of the villagers**: 65(previous it was 75+)
10. **What do villagers do when family members are sick?**

    The villagers are more dependent upon the Hirakud NAC hospital for their health related problem. However some villagers use various type of Herbal medicine, homeopathic medicines available in the nearer area. In case of any critical disease, the villagers have to depend upon the Burla medical hospital college. No health related awareness has not been conducted neither by the company nor by the plant authority.

11. **Which medicine do they prefer?** Villagers are dependent on the allopathic medicines prescribed by the doctors.
12. **Take bath every day**: Yes, maximum number of people uses the canal water, where as some people uses the water of the wells and tube wells.
13. **Washes clothes everyday**:

    It was found out that the villagers washes there cloth in a regular interval.

14. **What type of container they use for keeping water**: Mud pot, some uses plastic container such as large drum.
15. **Clean the drain regularly** The villagers do not clean their drain regularly.
16. **Put bleaching powder in the well**: rarely.
17. **Percentage of people who live and work in the city**: no data in found in this regard.
18. **Number of people with seasonal allergies that interfere with daily activities:**

    It is being found that maximum number of peoples suffers from dust allergies like sneezing, bronchial asthma, bronchitis and cold. The villagers are in the view that this problem has been multiplied after the initiation of the company. The villagers told that this problem gets aggravate during winter season due to formation of thick fog in this area.

19. **Number of death's per year due to HIV/AIDS:** No
20. **Literacy rate**:
21. **Access to potable water per capita:**

    Although the village has some 3 bore wells but all these get dried during summer days (April to June. The peoples depend upon the water of a pond during the summer season for bathing purposes. The canal water from the Hirakud reservoir has passed through this village.

22. **Average distance traveled to retrieve safe drinking water**: 500-1000 meter.

23. **Impact of the industrial activity on common peoples**:

This village is situated very close to the HINDALCO industry. The dust emitting from the chimney of the power plants falls in this village. This village was directly affected due to emission of chlorine gas from the smelter plant in 2003. Due to impact of this gas a large number of paddies got damaged for which there was a large scale of demonstration by the affected people before the company. The local farmers under the banner of *Krishka Sangha* made demonstrations before the district administration for proper compensation for the damage crops. Similarly the pot line waste (which belongs to hazardous waste category containing various poisonous chemicals like the **hydrogen fluoride**, and **cyanide**) of the company are being disposed nearer to the village grazing land site. These wastes are acidic in nature and having very high toxic nature. As there are no barricade found nearer to this side (till January, 2006) , the village cattle uses to enter this place and once they enter in this area, their foots becomes affected due to the acidic nature of this waste. The temperature of this village rises up to 55^0c during summer days and the temperature emission to the atmosphere by the industrial activity is responsible for it.

24. **Basic livelihoods of the villagers and affect of it due to industrial activity:**

Basically the villagers are farmers. Some of the peoples have got employment in the nearby industry and some villagers are doing some contract jobs for the industry. Majority of the villagers are depending upon agriculture as this area has the facility of irrigation water through out the year and having fertile soil. So the farmers are the real sufferers due to decrease in productivity of the paddy and vegetables due to impact of pollutants emitting from the industry.

25. **What do villagers think of the future?**

The villagers are in the view that after the commencement of the industrial activity in this area, the atmosphere has got polluted. Similarly the farmers are the worst sufferers as vegetation has been directly affected due to emission of various types of pollutants from the industry. Vegetables which were produced in a large number are not being produced in that amount, rather they are being affected by various type of diseases due to change in the local climate. In winter season the frequent occurrence of fog is damaging the vegetation to a greater extent.

SURVEY RESULTS OF VILLAGE – 3

1. **Name of the village and distance from the industry:** Jamadarpalli , 2 KM away from the industry.
2. **Total population**: 911 (male-481, female-430)
3. **SC & ST population**: 112(SC), 628(ST).
4. **Forest area**: Nil.
5. **Population affected due to industry**: Although no person from this village has been directly affected, but a number of villagers has been affected due to the pollution emission from the industry. The farmer groups are the most sufferers as their vegetable and paddy production has significantly reduced during the last 4- 5 years.
6. **Drinking water sources and present problem due to industrial activity**: Presently there are 6 tube wells found in this village. Out of this 2 tube wells has been constructed by the state government and one has been dug by the company. Except this a number of wells are also found in this village. But the problems of drinking water start in summer days when the water tables recedes very firstly. Out of the 6 tube wells 2 are not functioning now days and the rest get dries during summer days. Another major problem of drinking water is the settling of fly dusts emitting from HINDALCO power plant chimney. These dusts settle as a layer on the drinking water in morning. Except this a number of rice mills(2 numbers) are found in this area which contribute a large scale of thick black dust which settles on the water of well and pond. As these 2 mills belong to small scale category, they do not comply with the environmental norms thus aggravating the pollution situation.
7. **Medical facilities in the villages**: No. the villagers have to depend upon the Hirakdud NAC hospital for any health related problem and in case of emergency they depend upon the Burla medical college hospital which is some 10 KM away from here. Some villagers depend upon the private nursing home in Sambalpur.

   (a)- **Nearer health centre**: Hirakud NAC hospital.

   (b)- **Number of doctors visiting the villages**: NIL
8. **Diseases usually reported**: With interacting with the villagers it was found out that respiratory related disease, skin disease, water borne disease is commonly found in this village. Due to drinking of unhygienic water, a large number of peoples are suffering from different gastro-intestinal disease, jaundice (more common in summer season). Similarly the dust is causing various types of skin diseases like itching problem, small ulcers in the skin and allergy in eye. Some villagers also complain about the problem of joint pain especially in case of old peoples.
9. **Longevity of the villagers**: 65(previous it was 70+)
10. **What do villagers do when family members are sick?**

    The villagers are more dependent upon the Hirakud NAC hospital for their health related problem. However some villagers use various type of ayurvedic medicine, homeopathic medicines available in the nearer area. In case of any critical disease, the villagers have to depend upon the Burla medical hospital college.

11. **Which medicine do they prefer?**

    Villagers are dependent on the allopathic medicines prescribed by the doctors.

12. **Take bath every day**: Yes, some villagers use the pond for these purposes while some villagers use well and tube wells.

13. **Washes clothes everyday**: No

14. **What type of container they use for keeping water**: Mud pot, some uses plastic container such as large bucket, stainless steel utensils.

15. **Clean the drain regularly**- The villagers do not clean their drain regularly though some part of the village has drain facility.

16. **Put bleaching powder in the well**: yes but in frequent manner.

17. **Percentage of people who live and work in the city**: no data in found in this regard.

18. **Number of people with seasonal allergies that interfere with daily activities:** it is being found that maximum number of peoples suffers from dust allergies like sneezing, cold. The villagers are in the view that this problem has been multiplied after the initiation of the HINDALCO and other small scale industry like the rice mills.

19. **Number of death's per year due to HIV/AIDS: no**

20. **Literacy rate**: 53.8%

21. **Access to potable water per capita:** Although the village has 6 bore wells, 4 of these get dried during summers. The water from wells also gets dries up during summers.

22. **Average distance traveled to retrieve safe drinking water**: 500 meter.

23. **Impact of the industrial activity on common peoples**: This village is found very close to the HINDALCO industry. The dust emitting from the chimney of the power plants falls in this village. The villager complains that plant like drum stick, mangoes, and guava gets affected due to the dust falling and emission of gases like SO_X from the captive power plant of the industry. Similarly gases having foul odor emitting from the rice mills are causing a lot of problem.

24. **Basic livelihoods of the villagers and affect of it due to industrial activity:** Basically very few persons of this village (15%) are agriculturist as irrigation facility is not found in this village. Maximum number of the peoples work as laborer in the near by industry. The farmers are being affected due to non access of irrigation water and the pollution impact of the near by industry are aggravating this situation. Similarly some villagers those who have made guava, litchi, and mango cultivation in this area has been financially affected due to impact of pollutants.

25. **What do villagers think of the future?** The villagers are in the view that after the commencement of the industrial activity in this area, the atmosphere has got polluted. Similarly the farmers are the worst sufferers as vegetation has been directly affected due to emission of various types of pollutants from the industry. This village has been famous for growing various types of vegetables in winter season but now days this production has been drastically reduced due to non availability of irrigation water.

SURVEY RESULTS OF VILLAGE – 4

1. **Name of the village and distance from the industry:** Mohammedpur, 1 KM away from the industry.
2. **Total population**:
3. **SC & ST population**:
4. **Forest area**: Nil.
5. **Population affected due to industry**: Although no person from this village has been directly affected, but a number of villagers has been affected due to the pollution emission from the industry. Similarly a part of the crop was damaged in 2003 poisonous gas leakage from the industry.
6. **Drinking water sources and present problem due to industrial activity**: presently there are 5tube wells found in this village. Out of this one is functioning. Except this a number of wells owned by villagers are also found in this village. But the problems of drinking water start in summer days when the water tables recedes very firstly. Similarly dust emitting from the HINDALCO power plant chimney settles in this village as this village is found in the area where the dust settles. The problem aggravates in rainy season as the sulphur dioxide gas emitted from the chimney causes acid rain in this area.
7. **Medical facilities in the villages**: No. the villagers have to depend upon the Hirakdud NAC hospital for any health related problem and in case of emergency they depend upon the Burla medical college hospital which is some 20 KM away from here.

   (a)- **Nearer health centre**: Hirakud NAC hospital.

   (b)- **Number of doctors visiting the villages**: NIL.
8. **Diseases usually reported**: With interacting with the villagers it was found out that respiratory related disease, skin disease, is commonly found. Except this disease like arthritis, joint pain, are also found. Similarly due to drinking of unhygienic water a number of peoples are being affected with different type of gastro-intestinal disease. Allergy of skin and eye is commonly found in this area due to high load of pollutants in this area.
9. **Longevity of the villagers**: 60(previous it was 70+)
10. **What do villagers do when family members are sick?**

    The villagers are more dependent upon the Hirakud NAC hospital for their health related problem. However some villagers use various type of ayurvedic medicine, homeopathic medicines available in the nearer area. In case of any critical disease, the villagers have to depend upon the Burla medical hospital college.
11. **Which medicine do they prefer?**

    Villagers are dependent on the allopathic medicines prescribed by the doctors.

12. **Take bath every day**: yes, some villagers use the pond for these purposes while some villagers use well and tube wells.
13. **Washes clothes everyday**: No
14. **What type of container they use for keeping water**: Mud pot, stainless steel utensils and some use plastic buckets.
15. **Clean the drain regularly** No drain facility is found.
16. **Put bleaching powder in the well**: Yes.
17. **Percentage of people who live and work in the city**: no data in found in this regard.
18. **Number of people with seasonal allergies that interfere with daily activities:** it is being found that maximum number of peoples suffers from dust allergies like sneezing, cold. The villagers are in the view that this problem has been multiplied after the initiation of the HINDALCO as it is the only source of air pollution in this area.
19. **Number of death's per year due to HIV/AIDS:** Data not available.
20. **Literacy rate**:
21. **Access to potable water per capita:**

    Although the village has 5 bore wells but only one is functioning. The villagers have to depend upon the well water all through the year. But the well water is also getting bad due to deposition of fly dust emitting from the power plant chimney.
22. **Average distance traveled to retrieve safe drinking water**: 500meter.
23. **Impact of the industrial activity on common peoples**: This village is found very close to the HINDALCO industry. The dust emitting from the chimney of the power plants falls in this village. Similarly the village farmers are the worst sufferers due to decline in the production of vegetables and paddy. Although this village has the irrigation water facility, but the production level has marginally reduced now a days due to the impact of pollutants and various types of diseases.
24. **Basic livelihoods of the villagers and affect of it due to industrial activity:** large numbers of villagers are agriculturist as irrigation facility is found in this village. Similarly some of the women earns by Bidi making, as they collect the Kendu leaf from the near by area. The Kendu leaf are being collected from the small patch of forest located near the Larbanga forest. But due to disposal of fly ash nearer to this area, the kendu leaf are not growing marginally thus affecting the livelihood of the pluckers.
25. **What do villagers think of the future?** The villagers are in the view that after the commencement of the industrial activity in this area, the atmosphere has got polluted. Similarly the farmers are the worst sufferers as vegetation has been directly affected due to emission of various types of pollutants from the industry. But they are not getting any compensation for this reduction in quantity of crop. Similarly the district administration has not taken any concrete step to chalk out this problem.

SURVEY RESULTS OF VILLAGE – 5

1. **Name of the village and distance from the industry:** Dengimachha, 1 KM away from the industry.
2. **Total population**:
3. **SC & ST population**:
4. **Forest area**: Nil.
5. **Population affected due to industry**: This village is located very nearer to the plant site. This village is predominantly covered by farmers but farming now days is not giving profit as it used to give some 5 years back.
6. **Drinking water sources and present problem due to industrial activity:**

   All most all the family has their own wells. There is no drinking water problem found in this village, as this area has been irrigated by the canal raised from the Hirakud reservoir. How ever during the month of April to June and in December, the water supply in the canal remains closed thus creating major problem for drinking, bathing and other purposes.
7. **Medical facilities in the villages**: No. the villagers have to depend upon the Hirakdud NAC hospital for any health related problem and in case of emergency they depend upon the Burla medical college hospital which is some 20 KM away from here.

   (a)- **Nearer health centre**: Hirakud NAC hospital.

   (b)- **Number of doctors visiting the villages**: NIL.
8. **Diseases usually reported**: With interacting with the villagers it was found out that maximum of the villagers are affected due to respiratory related disease, skin disease. Except this disease like arthritis, joint pain, are also found. Similarly due to drinking of unhygienic water a number of peoples are being affected with different type of gastro-intestinal disease. The villagers especially the old persons are complaining about the occurrence of bone and joint pain.
9. **Longevity of the villagers**: 65(previous it was 75+)
10. **What do villagers do when family members are sick?** The villagers are more dependent upon Hirakud hospital for their health related problem. However some villagers use various type of ayurvedic medicine, homeopathic medicines available in the nearer area. In case of any critical disease, the villagers have to depend upon the Burla medical hospital college.
11. **Which medicine do they prefer?**

    Villagers are dependent on the allopathic medicines prescribed by the doctors.
12. **Take bath every day**: yes, some villagers use the pond for these purposes while some villagers use well and tube wells.
13. **Washes clothes everyday**: yes but the villagers face problem during the month of April, May and December when the water supply to the canal is being closed.
14. **What type of container they use for keeping water**: Mud pot, stainless steel utensils and some use plastic buckets.

15. **Clean the drain regularly-** no.
16. **Put bleaching powder in the well**: yes.
17. **Percentage of people who live and work in the city**: no data in found in this regard.
18. **Number of people with seasonal allergies that interfere with daily activities:** it is being found that maximum number of peoples suffers from dust allergies like sneezing, cold. The villagers are in the view that this problem has been multiplied after the initiation of the HINDALCO as it is the only source of air pollution in this area. The problem is found to be maximum during winter and monsoon period. During monsoon period even the villagers feel burning sensation when the rain drops fall on bare skin. It may be due to the formation of acid rain.
19. **Number of death's per year due to HIV/AIDS: no**
20. **Literacy rate**:
21. **Access to potable water per capita:**
22. The villagers are depending upon the well water all through the year. But the well water is also getting bad due to deposition of fly dust emitting from the power plant chimney. Similarly during the month of May and June the villagers face problem in accessing pure water.
23. **Average distance traveled to retrieve safe drinking water**: 100meter.
24. **Impact of the industrial activity on common peoples**: This village is found very close to the HINDALCO industry. The dust emitting from the chimney of the power plants falls in this village. Similarly the village farmers are the worst sufferers due to decline in the production of vegetables and paddy. Although this village has the irrigation water facility, but the production of paddies and vegetables level has marginally reduced now a days. The villagers are in the view that the crop production has significantly reduced since the commencement of industrial activity. The farmer forums are in the view that the production of rice is significantly less with comparison to other area of this district.
25. **Basic livelihoods of the villagers and affect of it due to industrial activity:** large numbers of villagers are agriculturist as irrigation facility is found in this village. The villagers practice double crops. Some villager grows vegetables in the field where some villagers rear cattle's. The industrial pollutants in the form of air, dust and solid waste has marginally affected the productivity of the vegetables, fertility of the soil.
26. **What do villagers think of the future?** The villagers are in the view that after the commencement of the industrial activity in this area, the atmosphere has got polluted. Similarly the farmers are the worst sufferers as vegetation has been directly affected due to emission of various types of pollutants from the industry. But they are not getting any compensation for this reduction in quantity of crop. Similarly the district administration has not taken any concrete step to chalk out this problem. Similarly the bovines of this area have been affected due to some unknown disease, but the veterinary doctors in charge could not confirm the nature of disease. The symptoms involve whitening of toes, and weakening of bone and skeleton. This has affected the agriculture in- directly.

LAND USE PATTERN OF THE STUDY AREA

The study area has two reserve forest (I) Landungir reserve forest and (II) Lakshmi dungri reserve forest to the east and south of plant. Within 3 Km radius of plant, HINDALCO has acquired 357 acres of land (GPS location of plant site $83^0$54'27''E, 21^0 31'54''N). During the field survey, a through study was carried out to find out the land use pattern within the 10 Km radius of the plant. It was found that the reservoir occupies a major portion of the 10 Km area around the plant site. The detail breaks up of the land use are as follows:

LAND USE PATTERN IN THE STUDY AREA

CATEGORY OF AREA	PERCENTAGE
Residential area	7.43%
Industrial area	0.07%
Crop land (standing)	10.52%
Crop land	5.17%
Degraded forest	5.08%
Forest plantation	0.59%
Land without shrub	18.58%
Rivers/ stream	4.07%
Reservoir	48.01%
Lake/ tank/ pond	0.38%
Ash pond disposal site	0.02%

LAND USE PATTERN WITHIN THE PLANT

Sl No	DESCRIPTION OF UNIT	AREA IN ACRES	AREA (in Ha)
1	**Smelter plant**	**28.46**	**11.52**
	a. Build up area	20.96	8.48
	b. Open space	7.50	3.04
2	**Power plant**	**31.81**	**12.88**
	a- build up area	23.81	9.64
	b- open space	8.00	3.24
3	**Colony building**	**20.01**	**8.10**
4	**Energy plant, lawn**	**66.19**	**26.80**
5	**Others**	**210.32**	**85.15**
	a. Captive power plant	16.00	6.48
	b. Ash pond	100.00	40.48
	c. Slurry pond	17.00	6.88
	d. Roads, railway	77.32	31.30
	Total area	**356.79**	**144.44**

IMPACT ON THE LAND USE PATTERN DUE TO INDUSTRIAL ACTIVITY

The HINDALCO which previously was known as INDAL has acquired 357 acres of land where the smelter plant, the captive power plant and other activities is taking place. Presently the company has further acquired about 100 acres of land in the west direction of the present location. Similarly, the company is using a large patch of land for disposal of its fly ash in village Larbanga. The impact of the industrial activity on the land use pattern can be described as follows:

I The fertile land in the core area (10 KM radius) has been severely affected due to deposition of fly ash emitted from the captive power plant and from the fly ash disposal site. In villages like Dengimaccha, Nuajamuda and Mohammedpur large patches of fertile agricultural lands have been transformed to barren lands due to severe impacts of pollution from Smelter Plant (These villages are located very close to the plant site).

II Reduction in pasture land due to dumping of fly ash in villages like Larbanga and Mohammedpur. Similarly in Nuajamuda village a large portion of village pasture land (government land) has been used for dumping of hazardous waste.

III There has been increase in the percentage of residential area, industrial area and ash pond disposal area when compared to the last 10 years.

IV The percentage of land under the category “land without shrub” has been reduced due to land acquisition near the company premises. This indicated that the vegetal cover would have simultaneously reduced. Similarly the forest plantation area has been reduced due to mismanagement by the concerned authority.

A complete hill top is being flattened out for the expansion of the plant and construction of the new plant building. As a result of blasting operations, the nearby ecosystem has been completely damaged – rubbles and stones keep falling out of these mountains occasionally, resulting in frequent accidents. Also, the local people are voicing their concerns that such frequent blasting operations can have deleterious impacts on the nearby Hirakud dam wall which might even develop cracks.

AIR POLLUTANTS EMITTED FROM THE SMELTER PLANT

HINDALCO which was previously known as INDAL (Indian Aluminum Company, Hirakud) has been in operation since 1961. The electrolytic pots were open horizontal stud Sodberg (HSS) with no device for emission control. Wet scrubbers have been added since 1994 to check the emission of fluorine into the environment. Smelting of Aluminium is done by reduction method by the Hall Heroult process. Apart from this, the company has its own captive power plant situated in its premises. Various types of emissions are found from the existing industrial complexes. Emission from the existing complex are gases such as SO_X, F, NO_X,. Particulate matter, coal tar pitch volatiles matter etc.

Emissions from the captive power plant: Gases like Sox, NOx and particulate matter are the main emissions from the captive power plant. The villagers complain that although the company has installed the ESP to check the particulate matter pollution, it generally does not run the ESP during nights and during rainy periods. The surrounding villages upto 5 km distance are the most affected due to deposition of particulate matter. This results in the development of various types of skin diseases, acute respiratory problems and ulcerations on the skin. Similarly the fly ash powder which disperses due to wind is slightly acidic in nature and when it gets in contact with the skin, it results in itching.

Pot room emissions (roof emissions): A number of pollutants are emitted from the pot room emissions. The pot room is the potential polluting site of the smelting industry. Various types of pollutants are emitted from this site and they are as follows:

I **Coal tar pitches, volatiles from Soderberg anode:** The people working in this unit are the most affected. The company has provided them with mask which is not effectively checking the respirable dust particulates from entering into their respiratory system. During our field visit we got to meet a number of workers of the company who are being affected with various types of respiratory problems. The diseases include Asthma, bronchitis, TB. But the workers are not interested in speaking out about their problems since they fear termination from their jobs.

II **Particulate and gaseous fluorides:** The workers of the company are being adversely affected due to particulate and gaseous fluoride problems due to the emissions from the green anode and anode baking shops which are mostly confined

to the work environment. The affected workers are asked by the company to get themselves checked up at private clinics instead of the government hospital. The Specific fluoride emission is 4.25 kg/ per one tones of aluminum

III **Emission from carbon paste plant:** Tiny carbon shoot is the main pollutants in this unit. So the workers in this unit face various types of acute respiratory problem. During our field visit one youth from Dengimaccha village (identity withheld on request) who is working in the carbon paste plant narrated that the fine carbon dust emitted from the site is not being efficiently checked by the mask provided by the company. He was complaining restlessness, problem in breathing and finally when his condition deteriorated, he was referred to Burla Government hospital where he was detected with black lung disease and asthma. Although the doctors had advised him to get himself shifted from this unit, the company authorities have not yet pay heed to his requests.

During our visit to the plant site, we experienced the strongly pungent smell of Chlorine gas which triggered nose running and irritation of our eyes throughout the day. Our experience forced us to think about the how the local people were bearing and tolerating such living conditions. Our interaction with a few farmers and households revealed that the smelter plant intermittently liberated a strongly odorous gas, which causes the vegetation to burn out and get charred.

Our interaction with a few workers of the pot room revealed that they were provided with a normal mask and a Japanese mask to protect themselves. However, inspite of using an additional towel to protect themselves, the workers ended up inhaling loads of finely powdered aluminium – fluoride mixture (because the technology used is still the old grandfather technology of open pot technique). As a result, the workers end up with respiratory ailments like allergic rhinitis, Asthma, Tuberculosis, etc. The people with whom we got to interact, told us that they were experiencing joint pain, pains in the bones, skin allergies and severe respiratory problems. The pot lining is discarded carelessly all over the place. The local people said that this material is so toxic that it even kills weeds. Inhaling the material can cause severe irritation and watering of the nose.

WATER ENVIRONMENT OF THE AREA

This plant is located close to the left bank of Mahanadi River. The river Mahandai flows south at an approximately distance of 1 km to the west of HINDALCO plant. Apart from Mahandai River, the study area has two major nallahs, Kharjor and Rapta Nallaha which carry run off water during monsoon season. Strom water from smelter plant and adjoining places are discharged in to Kharjor nallah. The Kharjor nallah finally joins the river Mahandai. Similarly a number of ponds and water tanks were found near the study site.

IMPACT OF INDUSTRIAL ACTIVITY ON THE WATER ENVIRONMENT

The Hirakud reservoir is very close to the industrial site. Although the wind rose pattern of this area shows that the reservoir does not comes in the direction of wind flow, the dispersion pattern from the plant covers the reservoir. But this seems to have less impact on the water quality of the reservoir due to high volume of water in the reservoir which dilutes the pollutants to a great extent. The industrial effluents have been found to be having adverse impacts on various small nallah passing through this area. People drink the water supplied through a pipeline from Hirakud reservoir. However, in the adjoining villages, where such water supply line is not available, they depend on underground water and use tube wells. Fluorosis is not a major problem in this area. The sludge pond is not lined with polythene material and all the red mud, and plant wastes are directly dumped into it without treatment. The water that percolates out of this sludge pond is directly released into Hirakud reservoir without any kind of treatment. Also, there is considerable contamination of the groundwater since the sludge pond lacks a polythene lining

I The Kharjor nallah which flows just adjacent to the plant site carries all the industrial effluent with it. As there is no polythene lining in the hazardous waste disposal site, the leachate generated from the site is directly carried into the nallah. Similarly during monsoon period, the storm water from the hazardous disposal site is carried out by this nallah. During the study period it was found that, a very less number of aquatic animals are found and it may be due to the presence of various hazardous elements in it. Similarly peoples are taking bath as they are less aware about the content of this water. This water is being directly discharged to the Mahandai River through this nallah and in summer days it can not get diluted. So the peoples using this water in down area like Sambalpur will be mostly affected due to this water.

II During our study period almost all the villagers complained about the deposition of soot particles emitted from the chimney of the captive power plants. The shoot particles get deposited as a thin layer on the water surface of wells and ponds of this area. So the villagers are forced to consume this polluted water in the absence of clean potable supply water.

III The waste effluents from the industrial site are not being properly treated. They are as such disposed into the nallahs. Similarly the sewage generated from the nearby colonies are not being treated before disposal into Mahanadi river.

CODING OF WATER SAMPLES

CODE NUMBER	PLACE OF SAMPLE COLLECTION
SW6	Larbanga
SW7	Mohamedpur
SW8	Near Plant Site (Temple)
SW9	Kharjor Nallah flowing close to the Slush pond area
SW10	Nuajamda

Analysis of Physio-Chemical Parameters of Water

Sl No	PARAMETERS / SAMPLES	S6	S7	S8	S9	S10	Desirable Limit
1	Colour	Light yellow	Light yellow	Yellowish	Grayish brown	Clear	**Clear**
2	Odour	Odour free	Odour free	Odour free	Odour free	Odour free	**Unobjectionable**
3	pH at 25° C	6.82	6.91	6.2*	5.6*	7.2	**6.5 to 8.5**
4	Conductivity µS	621	640	835	934	542	**-**
5	Total Hardness (as $CaCo_3$) mg/lit	52	48	72	160	156	**300**
6	Phenolphthalein Alkalinity mg/lit	0	0	0	0	0	**-**
7	Total Alkalinity mg/lit	220*	260*	94	88	102	**200**
8	Chloride (as Cl) mg/lit	11.2	9.6	112.07	186.5	8.6	**250**
9	Nitrate (as NO_3) mg/lit	ABS	ABS	10	20	ABS	**45**
10	Nitrite (as NO_2) mg/lit	0	0	0	0	0	**-**
11	Arsenic (as As) mg/lit	0	0	0	0	0	**0.05**
12	Iron (as Fe) mg/lit	ABS	ABS	< 0.3	0.5*	ABS	**0.3**
13	Fluoride (as F) mg/lit	0.5	0.5	1-1.5*	1.0	0.5	**1.5**
14	Turbidity (NTU)	1.9	2	3.2	30*	2	**5**
15	Calcium (as Ca) mg/lit	11.5	6.73	46.3	47.2	7.9	**75**
16	Cadmium	ABS	ABS	ABS	ABS	ABS	**0.01**
17	Chromium (as Cr^{6+})mg/lit,Max	ABS	ABS	ABS	ABS	ABS	**0.05**
18	Sulphate (as SO_4) mg/lit,Max	16.3	14.0	230.2*	244.2*	26.4	**200**
19	Aluminium (as Al) mg/l,Max	ABS	ABS	ABS	ABS	ABS	**0.03**

* **Beyond Permissible limits**

* **ABS – Absent in water sample**

Indian Standard Drinking Water –Specification (BIS 10500 : 1991)

Sl.no	Substance or Characteristic	Desirable Limit	Permissible Limit
ESSENTIAL CHARACTERISTICS			
1.	Colour, (Hazen units, Max)	5	25
2.	Odour	Unobjectionable	Unobjectionable
3.	Taste	Agreeable	Agreeable
4.	Turbidity (NTU, Max)	5	10
5.	pH Value	6.5 to 8.5	No Relaxation
6.	Total Hardness (as $CaCo_3$) mg/lit.,Max	300	600
7.	Iron (as Fe) mg/lit,Max	0.3	1.0
8.	Chlorides (as Cl) mg/lit,Max.	250	1000
9.	Residual,free chlorine,mg/lit,Min	0.2	--
DESIRABLE CHARACTERISTICS			
10.	Dissolved solids mg/lit,Max	500	2000
11.	Calcium (as Ca) mg/lit,Max	75	200
12.	Copper (as Cu) mg/lit,Max	0.05	1.5
13	Manganese (as Mn)mg/lit,Max	0.10	0.3
14	Sulfate (as SO_4) mg/lit,Max	200	400
15	Nitrate (as NO_3) mg/lit,Max	45	100
16	Fluoride (as F) mg/lit,Max	1.9	1.5
17	Phenolic Compounds(C_6H_5OH)mg/lit,Max	0.001	0.002
18	Mercury (as Hg)mg/lit,Max	0.001	No relaxation
19	Cadmiun (as Cd)mg/lit,Max	0.01	No relaxation
20	Selenium (as Se)mg/lit,Max	0.01	No relaxation
21	Arsenic (as As) mg/lit,Max	0.05	No relaxation
22	Cyanide (as CN) mg/lit,Max	0.05	No relaxation
23	Lead (as Pb) mg/lit,Max	0.05	No relaxation
24	Zinc (as Zn) mg/lit,Max	5	15
25	Anionic detergents (as MBAS) mg/lit,Max	0.2	1.0
26	Chromium (as Cr^{6+})mg/lit,Max	0.05	No relaxation
27	Polynuclear aromatic hydrocarbons(as PAH) g/lit,Max	--	--
28	Mineral Oil mg/lit,Max	0.01	0.03
29	Pesticides mg/l, Max	Absent	0.001
30	Radioactive Materials i. Alpha emitters Bq/l,Max ii. Beta emitters pci/l,Max	 -- --	 0.1 1.0
31	Alkalinity mg/lit.Max	200	600
32	Aluminium (as Al) mg/l,Max	0.03	0.2

DEDUCTIONS

Water samples were collected from 5 various locations (both core & buffer area) as per the sampling guidelines. These samples were analyzed at the laboratory of VASUNDHARA. The samples were sent to the laboratory of the state pollution control board for analysis of heavy metals. The detailed analyses report of the water samples at different locations are given in the above table.

The pH value of the water samples collected from the Kharjor nallah and from the plant site area was found to be low (acidic in nature). This can be attributed to the untreated waste water from the plant site and from the sludge pond which is directly released into the Kharjor nallah. The high sulphate content of the water collected from this area can be said to be responsible for the low pH levels.

The turbidity of this nallah was found to be very high. Various parameters such as the sulphate, turbidity, fluoride and iron content of this Nallah and the water collected from the plant site were found to be high. This may be due to the presence of various types of chemicals leaching out from the processing plant of the company.

The fluoride content in the above mentioned 2 areas are found to be very high and this may be due to the release of fluorine gas from the smelter plant unit. It was found that the waste overflow water from the treatment plant is being directly released into this nallah thus resulting in high turbidity levels. Parameters of the drinking water samples collected from the wells of villages like Larbanga, Nuajaumda and Mohammedpur is found to be well within the limit prescribed by the BIS. The water samples collected from the Nuajamuda village are also found to be within the prescribed limits. However, from these results, we cannot conclude that the water is free from pollutants because the constant flow of fresh water from the reservoir through this village is diluting the levels of various pollutants. However, only a complete analysis throughout the year can predict the true water quality of this area and reflect the impacts of plant effluents on the physical and chemical composition of the surrounding water bodies.

WATER SCARCITY DUE TO INDUSTRIALIZATION: FUTURE SCENARIO

With rapid industrialization and urbanization, abundant natural resources like water tend to get limited. For instance, Rengali block of Sambalpur district has been declared as a drought prone area by the State Administration although this block is located very close to Hirakud reservoir.

From its date of commencement since 1960, the major objective of the multipurpose Hirakud dam was to **irrigate land** in districts like Sambalpur, Bargada, Jjharsuguda, and in some coastal districts followed by **flood control**, **hydro-electricity generation** followed by **Aquaculture** and **navigation purposes**. However, presently the state government has signed MOUs with various industries to supply 478.72 cusec of water every day. According to a report curently OPGC is drawing 12.36 cusecs of water, MCL Bandhabahal is drawing 3.71 cusecs of water, orient paper mill is drawing 1.84 cusecs of water, railway Jharsuguda is drawing 2.47 cusecs of water, Sambalpur PHD is drawing 7.46 cusecs of water, HINDALCO at hirakud is drawing 10 cusecs of water and Bhusan ltd is drawing 100 cusecs of water. Additionally, industries like IB Thermal Power (53 Cusecs), MFC Power Generation (2.45 Cusecs), Sterellite Opticals Technology (11.30 Cusecs), Aditya Alumina (52.73 Cusecs), Shyam DRI (11 Cusecs) have been permitted to withdraw water from the reservoir. Industries like SPS Sponge Iron (30 Cusecs), Arian Ispat(20 Cusecs), HINDALCO, Hirakud(25 Cusecs), Axin Ispat Ltd (4.58 Cusecs), and Viraj Steel(10.80 cusecs) has applied for drawing water from the reservoir.

In the upstream of the reservoir, MCL IB valley is drawing 4.020, Lilari Open Project 0.083; Lakhanpur open cast project 0.340, and Tata refractory, Belpahad is drawing 1.050 cusecs of water while Agragamee Steel has been allowed to withdraw 4.23 cusecs of water. The Eastern & Power has applied for withdrawing 10.30 cusecs amount of water from Hirakud reservoir. So the Government has given clearance to withdraw a total of 478.72 cusecs of water for consumption by the above mentioned industries.

The Main Project Report of Hirakud dam states that a total land area of 2,35,477 hectare (1,59,106 hectare of Kharif and 76,371 hectare of Rabi) would be irrigated by this project. But presently due to heavy sediment deposition in the dam (27% of the height), the water retention capacity of this dam has been marginally reduced. So at this crucial juncture, withdrawing 478.72 cusecs of water per day will definitely put an adverse impact on the hydroelectricity generation and Irrigation capacity of the dam. According to Hydrology Experts – 1 cusecs of water can irrigate about 100 acres of land – withdrawal of 478 cusecs of water per day will deprive 47 thousand acre of land from being irrigated. This clearly depicts the bleak future of farmers in this area, whose fields would be deprived of irrigation water which will ultimately affect the livelihood of thousand of people in the state.

INFORMATION ON WITHDRAWL OF WATER FROM HIRAKUD RESERVOIR

Sl no	Name of the agency	Product	Location	Requirement of water (Cu)	Source	Status
1	M/S O.P.G.C Ltd,(Ib thermal power station)	Electricity	Banharpalli, Jharsuguda	53	Hirakud reservoir.	Permission granted
2	M/S HINDALCO, hirakud	Aluminum	Hirakud	10	Sambalpur distributary.	Permission granted
3	M/S Aditya aluminum	Aluminum	Lapanga, Jharsuguda	52.73	Hirakud reservoir	Permission granted
4	M/S Bhusan ltd.	Steel	Lapanga, Jharsuguda	12 (at present) 100 (in future)	Hirakud reservoir	Permission granted
5	M/S Rathi steel & power project ltd.	Steel	Potapalli	10	Hirakud power channel	Clearance Awaited
6	M/S S.S.P.S sponge iron ltd	Sponge iron	Barmel, Jhaarsuguda	10 (1^{st} phase) 20 (2^{nd} phase)	Hirakud reservoir	Clearance Awaited
7	M/S Sterllite pvt.Ltd	Sterlite	Jharsuguda	40-60 MGD	Hirakud reservoir.	Clearance Awaited
8	M/S HINDALCO , 100 MW thermal power plant.	Electricity	Hirakud	10	Hirakud reservoir.	Clearance Awaited

SOLID WASTE POLLUTANTS

The solid wastes from smelter plant include spent pot lining, wet scrubber sludge, and metallic dross.

SOLID WASTE GENERATED FROM SMELTER PLANT

Sl No	Solid Waste	Source	Quantity Generated (MTPA)
1	Spent pot lining	Pots	984
2	Wet scrubber sludge	Wet scrubber	2520
3	Metal dross	Holding furnace	200

The nature of waste: Spent pot lining contains 10-12% fluoride and 0.5-0.8% cyanide; Scrubber sludge contains HF, (5475 MT of scrubber sludge per annum is currently generated by the plant). It was found that these hazardous wastes are being dumped near the village Nuajamuda. No precautionary measures were undertaken to dispose off this waste. The slush pond is supposed to be lined with polythene to prevent leaching out of concentrated and toxic pollutants. Unfortunately, the slush pond has no polythene lining at all (**Slush Pond Photograph enclosed**).

Similarly, this area had not been fenced till January 2006. The villagers complained that, the cattle enter this area and get severely affected with ulcers in their hoofs, patches and inflammation on their body since they unknowingly come in direct contact with these hazardous wastes. The leachate generated from this site is being drainage to nearby Nallha.

Fly ash dumping: The fly ash generated from the captive power plant is being used for preparation of Portland grade cement. Similarly a portion of fly ash is being disposed in the fly ash disposal site located near Larbanga. Prescribed Environmental Guidelines are not being complied with during the dumping of fly ash. During the dumping of fly ash at the disposal site it was found that a lot of dust pollution arises for which no precautionary measures are being taken. This dust settles on the nearby vegetation. Similarly, the water sprinkling system for suppression of dust is not being properly followed during the transportation and disposal of fly ash.

The pot lining was discarded carelessly all over the place before February 2006. The local people said that this material is so toxic that it even kills weeds. Inhaling the material can cause severe irritation and watering of the nose

TYPICAL ANALYSIS OF SPENT POT LINING WASTE

SL NO	PARAMETER	CHARACTERISTICS	
		CARBON BLOCK	INSULATION BLOCK
1	PH	10	10 %
2	Carbon	45-50 %	-
3	Aluminum	4-6 %	25 %
4	Silica	1-1.5 %	-
5	Iron	0.5-1 %	-
6	Sodium	15-20 %	19 %
7	Fluoride	10-12 %	8 %
8	Aluminum carbide	0.2-0.5 %	-
9	Cyanide	0.01-0.025 %	-
10	Others	10-15 %	-

(AS REPORTED BY INDUSTRIES)

Sl.No	PARAMETERS	CARBON BLOCKS	INSULATION BLOCKS	BLACK MUD
1	PH	9.3	9.8	8.9
2	Iron(total)	1.5-2.5	-	2-4
3	Iron (lechable)	0.02-0.05	-	0.03-0.08
4	Sodium	12-18	15-20	18-22
5	Sodium (lechable)	6-10	5-8	3-8
6	Fluoride (total)	12-18	10-14	3-8
7	Fluoride (leach able)	4-8	2-5	1-3
8	Cyanide(total)	0.1-0.3	-	0.05-0.15
9	Cyanide (lechable)	0.01-0.029	-	0.02-0.1

(AS REPORTED BY NATIONAL PRODUCTIVITY COUNCIL)

Based on the reports of National Productivity Council and from the Industries report, the hazardous nature of spent pot lining can clearly be established. Even in the spent pot lining samples that we had collected from near the HINDALCO plant site (and analyzed in our laboratory), the Total Iron and Fluoride content were found to be much beyond the permissible limits.

FLORA AND FAUNA STUDY

Since the area belongs to semi urban area, the wild animal population as such is observed to be very low. Only birds, reptiles, amphibians, insects and a few mammals could be recorded from the area around the project site.

CHECKLIST OF FAUNA OF CORE AND BUFFER AREA

A	**Insects**	Various kinds spiders, butterflies, grasshoppers , mites and aphids
B	**Amphibians**	Bufo melanostictus, Rana tigrina
C	**Reptiles**	Water snakes, cobra, crates, lizards.
D	**Molluscs**	Edible snails and bivalves
E	**Birds**	Indian pond heron, little egret, cattle egret, red jungle fowl, owls, Indian koel, common myna, black headed bulbul, paddy field warbler, Indian house sparrow, red munia, Indian spotted munia, peafowl, and a number of migratory birds during winter season.
F	**Mammals**	Common mongoose neyul, Indian squirrel, Bandicoot rat, cats, dogs, goats, cows, buffaloes, sheep, hare.
G	**Migratory birds**	Great cressed grebe, little grebe, spotbill , little cormorant, Indian shag, darter, pond heron, grey heron, purple heron, night heron, egrets, painted stork, white stork, black ibis, flamingo and kestrel,

The forest cover in this area can be classified as tropical dry mixed deciduous type. The study area(within 10 km radius of the plant) has two reserve forest (I) Landungir reserve forest and (II) Lakshmi dungri reserve forest to the east and south of plant. During the study period it was founded out that, villages like Dengi machha, Mohammadpur, has less number of plant cover. But in area like Larbanga, a good plantation was found. Some part of this plantation is natural while some are being developed by the HINDALCO authority under the plantation programme. However the plantation near the fly ash disposal site are found to belongs to exotic species like the Eucalyptus, Deodaru and acacia . The two reserve forests found in this location are having good growth. The detailed descriptions of the species located in this jungle are as follows.

While the tree layer is predominantly richer with *Zizyphus jujube,* other deciduous elements like *Termionalia tomentosa, T. bilirica, Cleistanthus patulus, Anogeissus latifolia, Holarrhena, pubescens*, *Acacia auriculaeformis, Aegel marmelos, cassia fistula, Magnifera indaicca, Mimusops*

elangi, Pongamia pinnata, Ficus glomerata, Tamarindus indica, etc occupy the upper and lower canopies. The shrubby layer includes *Cleistanthus collinus, Gardenia gummiofera, Zizyphus oenoplea, Helicteres isora, Flemingia* etc. The climbers are not found abundantly in this area, but some species like *Gymnema sylvestre, Tylophora indica, Dioscorea bulbifera* etc make the composition. Herbaceous growth is luxuriant in rainy season and grasses are usually found in large number. The common are- *Tridax procumbens, Evolvulus alsinoides, Andrographis indicus, Eragrostis coaractata, Hedyotis affinis, Rungia pectinata, P. urinia etc.*

Plantation around the Smelter Plant

HINDALCO has undertaken plantation in the area demarcated for plantation programmes. Until February 2006, the fly ash was dumped indiscriminately over the entire area. However, recently the flyash dumping site has been properly leveled and plantation has been undertaken on scientific grounds. Discrete patches of tress species of forestry importance like eucalypatus and acacia have been delineated as plantation in the area. Plantation made by the plant authority was located in villages like Larbanga, Nuajamuda and Jamadar palli. However there has been no plantation found in and around the industry premises. Similarly the plantation made by the company authority is of exotic species. The plantation programme near the fly ash dumping site is having a good growth.

IMPACT ON FLORA AND FAUNA DUE TO SMELTER PLANT EMISSIONS

Impact on vegetation due to Acidic Fumes and Emissions: During our visit, we witnessed the strongly pungent smell of Chlorine gas throughout our stay which triggered nose running and irritation of eyes in us. Our experience forced us to think about how the local people were tolerating such living conditions. Our interaction with a few farmers and households revealed that the smelter plant occasionally liberated a strongly odorous gas, which causes the vegetation to burn out and get charred. This incident recurs frequently and the wind direction in which the fumes are carried decides the fate of vegetation in that direction. The rest of the area (which does not fall in the wind direction) remains relatively unaffected. Particularly affected are the Drumstick plants and the paddy fields – during each such episode of emission, these plants dry up completely with a surprising quickness and just cannot regrow.

The impact of smelter plant on aquatic life and fishes is extremely evident. The villagers have reported that they are now looking for alternative means of income as fishing in the Hirakud reservoir is no longer fruitful. They have invested a lot of money in purchasing nets for fishing. However, due to the discharge of wastes not only from HINDALCO, but also from other industries in the vicinity, fishes are unable to survive and therefore, fishing as an occupation is no longer able to sustain them. The cattle are reported to be limping as a result of which, they are taken to the cattle market and sold or exchanged with new cattle.

Slush Pond of M/S HINDALCO Smelter Plant

P.N. The Dyke of the Slush pond is cracked and the untreated pond water flows out into nearby nallahs and low lying land areas

P.N. The Slush pond has not been provided with polythene lining so the pond water constantly leaches out from the bottom and sides of the pond.

HEALTH SURVEY AROUND THE SMELTER PLANT AREA

Our interaction with a few workers of the pot room revealed that they were provided with a normal mask and a Japanese mask to protect themselves. However, inspite of using an additional towel to protect themselves, the workers ended up inhaling loads of finely powdered aluminium – fluoride mixture (because the technology used is still the old grandfather technology of open pot technique). As a result, the workers end up with respiratory ailments like allergic rhinitis, Asthma, Tuberculosis, etc. The people with whom we got to interact, told us that they were experiencing joint pain, pains in the bones, skin allergies and severe respiratory problems.

The pot lining is discarded carelessly all over the place. The local people said that this material is so toxic that it even kills weeds. Inhaling the material can cause severe irritation and watering of the nose and one local person boasted that his family inhales the pot lining material when affected by severe cold, because the material relieves one from blocked nose, and sets the nose running. We tried to explain to him never to repeat that practice and explained the dangerous consequences to him.

Even the cattle are developing skeletal deformities and are reported to be limping. Their hooves turn patchy white and get decolorized in a matter of few months as a result of which, they are taken to the cattle market and sold or exchanged with fresh new cattle.

Acute Upper Respiratory Tract Infections, ART(I) is the most predominant health problem in this area owing to the heavy dust pollution. People of all age groups are affected with this problem but the significantly vulnerable group includes infants and elderly people of this area. The plant switches off its ESP during nights as a result of which there is immense dust pollution which becomes all the more evident during nights and early mornings. During the year 2005 March to 2006 March, about 7349 persons were diagnosed with ART(I) out of which 7297 persons were men while the rest 52 were women. The pot room workers complain of heavy respiratory problems which can directly be correlated to their occupational exposures to finely powdered aluminium – fluoride mixture and carbon powder, which are used during the production process. This problem magnifies during summers but gets somewhat minimized during rainy season.

Amoebiasis is the next predominant health problem in this area. The villagers lack health consciousness and use the running water flowing just outside their homes for drinking and cooking purposes without even boiling it. This continuously flowing stream of water is also used for washing clothes, bathing and cleaning purposes upstream which finally flows down and merges with the reservoir water. As a consequence of consuming such unhygienic water, people often fall prey to Amoebiasis and other water born diseases. Most of the cases go unreported while only the emergency cases merit hospitalization and manage to find place in the hospital records.

Skin Infections are also the result of bathing using unclean water loaded with detergents, fecal matter, waste food materials, fertilizers and pesticides, fly ash leachates and air borne pollutants which are washed off into the stream by the rains. Skin ulcerations and rashes are very common although people do not prefer to seek medical aid for this problem and very few cases are registered in the hospital records. The problem is very common during rainy season when fly ash gets mixed with the rainwater (due to absence of proper embankment to hold back the fly ash). The flyash is hazardous in nature and can cause severe inflammation if it comes in contact with the skin.

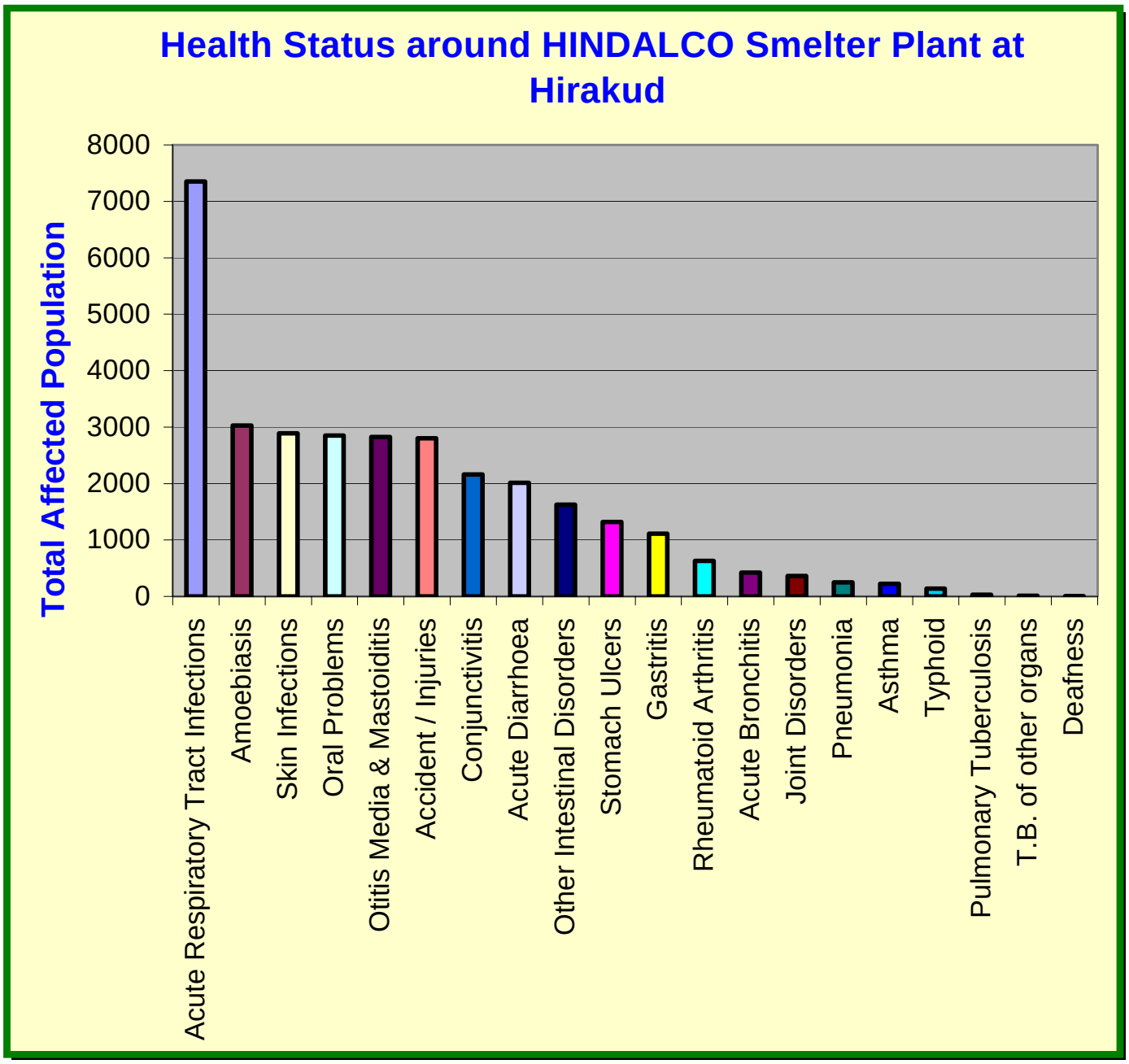
Oral problems are also very common in this area. The fluorine levels of the water samples collected from these areas indicate fluorine values within the permissible range and hence no instances of Fluorosis are reported. However, symptoms similar to Fluorosis have been reported from all villages surveyed by us. Surprisingly, the doctors of Government Hospital, Hirakud and Burla Hospital opine that since the people are habituated to eating *Paan* or *Gutka* they are afflicted with oral problems such as mouth ulcers, teeth decay, teeth staining, gum problems, etc. Oral cancers are not reported.

Hearing Impairment is a very common problem among the smelter plant workers and can be termed as an occupational disorder. The workers are subjected to very high noise levels created by ventilators, compressors, generators and transporting vehicles. Not all the workers are supplied with ear plugs and ear protection devices, while those who have been supplied with one, do not bother to use them. As a result, a large number of the work force is afflicted with either temporary or permanent hearing disorders. Stress due to high noise levels often results in stomach ulcerations as can be seen in this case also. About 1320 people from the study area had sought medical help and had been diagnosed with stomach ulcers.

Accidents/Injuries are very common within and around the plant site. The infrastructural facilities and roads are not well developed – the roads are narrow and there is inadequate space for pedestrians. As a result, accidents with speeding trucks carrying raw materials or transporting finished goods are very common in this area. Even occupational accidents and burn injuries within the plant is common in the workers involved in production units.

Conjunctivitis is a common problem among the workforce who do not follow even the minimum steps for maintaining self – hygiene and often end neglecting the problem as a result of which the infection keeps recurring and spreading to other susceptible victims.

Gastritis is again a common problem but it is common even among women. This can be attributed to the higher sulphate levels and low P^H of drinking water of this area. Other health problems include arthritis, bronchitis, pneumonia, typhoid and Asthma.


Health Status around HINDALCO Smelter Plant at Hirakud
Total Affected Population
8000
7000
6000
5000
4000
3000
2000
1000
0
Acute Respiratory Tract Infections
Amoebiasis
Skin Infections
Oral Problems
Otitis Media & Mastoiditis
Accident / Injuries
Conjunctivitis
Acute Diarrhoea
Other Intestinal Disorders
Stomach Ulcers
Gastritis
Rheumatoid Arthritis
Acute Bronchitis
Joint Disorders
Pneumonia
Asthma
Typhoid
Pulmonary Tuberculosis
T.B. of other organs
Deafness

MAJOR TYPE OF DISEASE PREVALENT IN THIS AREA

Sl No	HEALTH PROBLEMS	AFFECTED POPULATION		
		MALE	FEMALE	TOTAL
1	Acute Respiratory Tract Infections	7297	52	**7349**
2	Amoebiasis	3012	18	**3030**
3	Skin Infections	2888	0	**2888**
4	Oral Problems	2849	0	**2849**
5	Otitis Media & Mastoiditis	2825	0	**2825**
6	Accident / Injuries	2800	0	**2800**
7	Conjunctivitis	2160	0	**2160**
8	Acute Diarrhoea	2000	11	**2011**
9	Other Intestinal Disorders	1627	0	**1627**
10	Stomach Ulcers	1319	0	**1319**
11	Gastritis	1011	97	**1108**
12	Rheumatoid Arthritis	628	0	**628**
13	Acute Bronchitis	419	0	**419**
14	Joint Disorders	363	0	**363**
15	Pneumonia	210	38	**248**
16	Asthma	189	33	**222**
17	Typhoid	128	12	**140**
18	Pulmonary Tuberculosis	28	0	**28**
19	T.B. of other organs	9	0	**9**
20	Deafness	5	0	**5**

IMPACT ON LIVELIHOOD & SOCIO- ECONOMIC ENVIRONMENT

HINDALCO is a well established private company which has employed a large number of people (out of which very few are local people). Displaced people have been duly compensated and some have even been offered jobs in the company after completing their training successfully. The area where we visited was well connected with Hirakud reservoir and therefore, the basic occupation of people here is farming.

Most of the population in this area is engaged in farming as an occupation. But the periodical gas leaks, scattering of hazardous wastes indiscriminately all over the farming lands, and other deleterious impacts of emissions from the smelter plant have taken their toll on the production levels. Vegetable growers and paddy cultivators are the worst sufferers. At present, the production levels have fallen to 1/3rd of what it used to be 60 years back when the smelter plant was not yet established.

The fishermen community is severely affected due to the release of effluents from the smelter plant and a lot of other industries in the surrounding belt. Excessive withdrawal of water from the reservoir for industrial use is yet another serious factor which contributes to a sharp decline in fish catch over the past few decades.

Kendu leaf pluckers in this area complain about the poor market receptivity for the leaves plucked from this area. Exposure to acidic fumes and deposition of hazardous fly ash as a fine layer on the surface of leaves reduces the photosynthetic efficiency. This finally results in discoloration, spotting and chlorosis of leaves. Kendu leaves in this area appear unhealthy and therefore, their market is badly affected. Most of the Kendu leaf pluckers have taken up alternative means of livelihood and even shifted to urban areas in search of jobs.

Milkmen in this area find their cattle sick after consuming hazardous waste (fly ash / pot lining which are indiscriminately thrown around the plant site) laden grass. As a result, milk production has decreased and even the health of cattle is continuously found to be degrading. The milkmen around the plant site are now selling off their lands and migrating to nearby urban areas in search of jobs and alternative means of livelihood.

On the face of it people appear to be happy with their lives and lifestyles. However, there is a silent anger prevailing in the minds of the local people, who have been living here since their forefathers' time. However, they hardly have the courage or the means to express the reason for their annoyance against such a big company.

CONCLUSION

Owing to its inherent qualities like light weight, high strength, good thermal and electrical conductivity, corrosion resistance and non-toxicity, Aluminum holds a pretty positive image in the global marketplace. The metal's shiny exterior glimmers like an antidote to its heavyweight competitor, steel, or its lightweight, cheap-feeling counterpart, plastic. It holds this image despite the earth – and bone – shattering reality of its production.

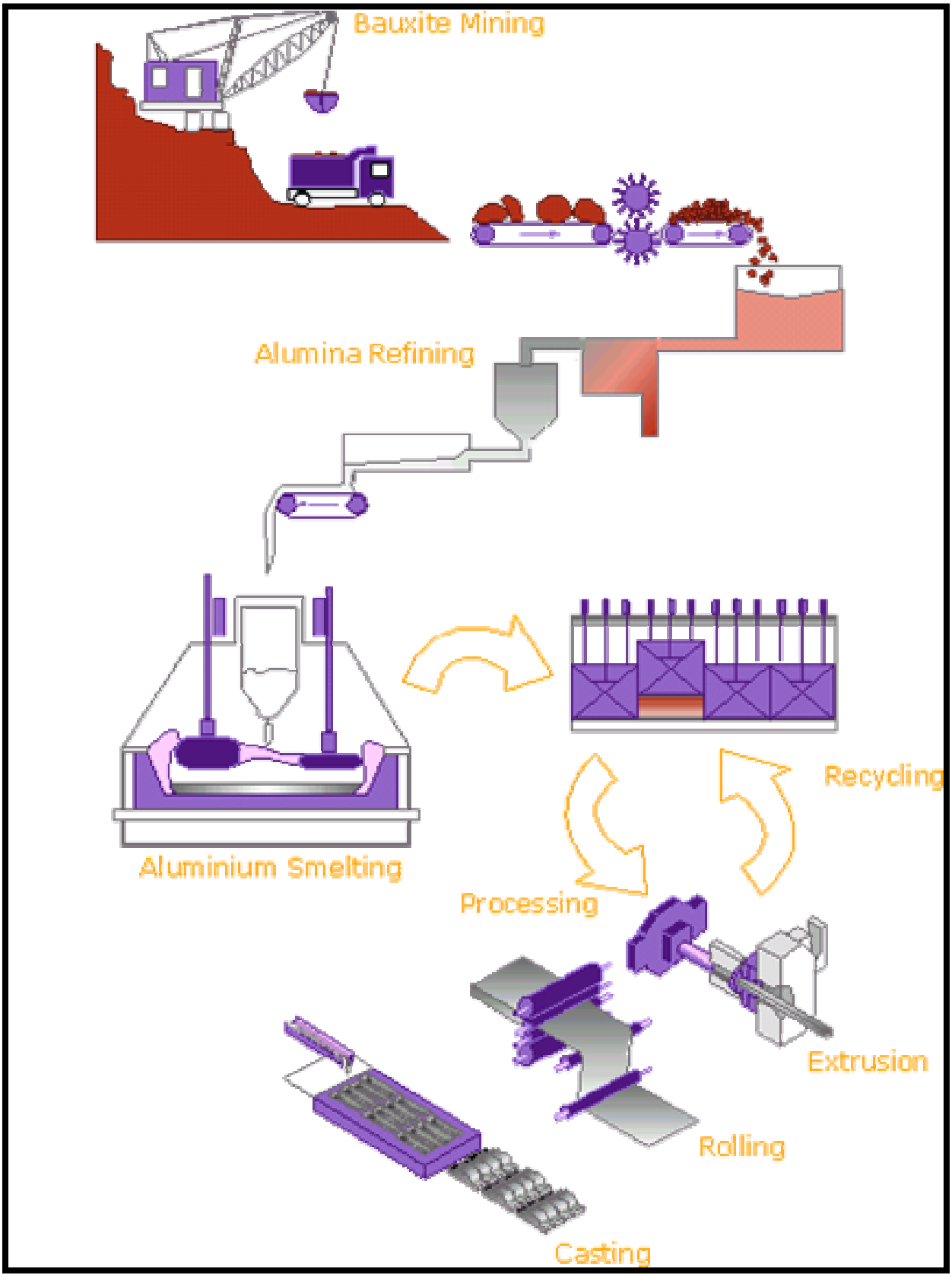
With abundant bauxite reserves and cheap labour, aluminium smelting is on a rise in India. Orissa holds about 10 percent of global and 70 percent of Indian bauxite reserves. Coal and hydro power provide cheap sources for existing and proposed smelters. Labor is also inexpensive, thus foreign corporations have rushed to proliferate bauxite mining, aluminium refining and aluminium smelting in India.

In the name of the "upliftment of backwards tribes" – or perhaps just corporate profits – Orissa has entered the list of transnational corporations' favorite sources of bauxite and alumina. In a short time, the aluminum industry's blasting, refining, smelting, and coal-fired power operations have already created a legacy of forced removals of people from their villages, ruined temples, destroyed forests, poisoned rivers, brittle bones, and dirty air. Orissa's early experiences with this industry have compelled many people to campaign for a halt to bauxite mining and smelting. Corporate investors and the State and National Governments have ignored or squashed the dissident voices.

This export-oriented industry is heavily subsidized by the Indian government, which is eager to move big industries into regions it has labeled as "backward areas." India offers 100% export-oriented industries exemption from paying income taxes. It also drops import tariffs for equipment used in these plants. Companies utilizing these loopholes defend them as a means to uplift the poor. Most of the bauxite mines and aluminium smelters are granted clearances on the pretext that – the State of Orissa and the Indian Government have a commitment to develop the backward districts of Kalahandi and the adjoining regions and that a project of this type will lead to infrastructure development, creation of modern townships, schools, medical facilities and direct employment to a large number of local people.

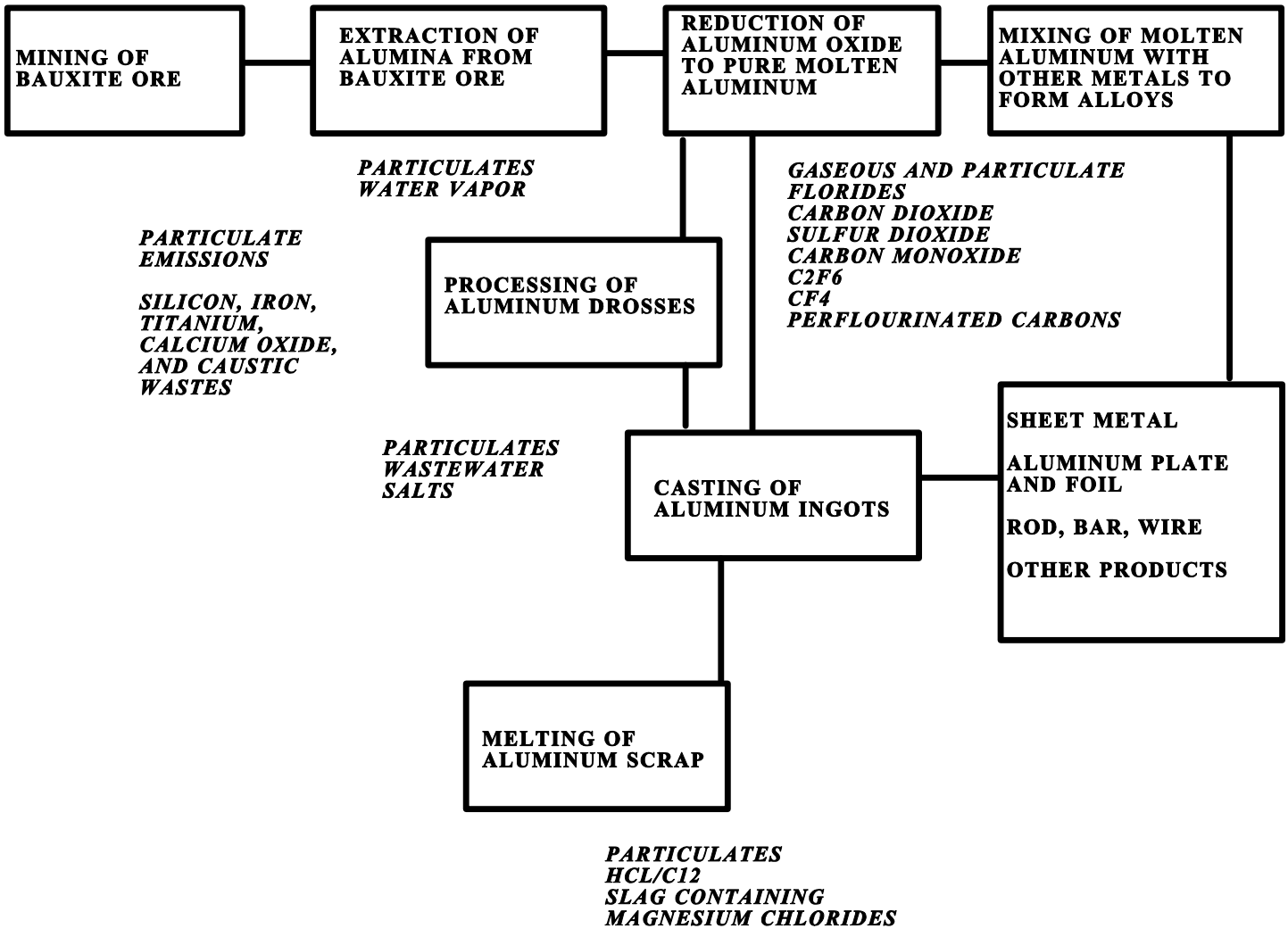
However, the fact, according to the growing number of people campaigning against them is that, these plants are tearing the social fabric of life in many parts of Orissa. Opponents of the new mines, refineries and smelters are trying to protect their history and their communities in order to secure their future. They argue that while the industry is there, riches may flow to some people in the region, but when the bauxite deposits are gone, the modern townships, schools and hospitals will almost certainly disappear with them. Only a legacy of environmental and social destruction will remain…..

Annexure - 1


Bauxite Mining
Alumina Refining
Aluminium Smelting
Recycling
Processing
Extrusion
Rolling
Casting

Annexure - 2

FIGURE 2: ALUMINUM PROCESS AND POLLUTION OUTPUTS



Annexure – 3

Aluminum Production

The main chemical exposures of concern in this industry have been fluorides (as hydrogen fluoride gas and as particulate), polycyclic aromatic hydrocarbons (PAHs), and the gases carbon monoxide and sulphur dioxide. Various studies of existing facilities have demonstrated worker exposures in excess of the appropriate occupational exposure limits. Additionally, the various physical factors (heat stress, electromagnetic fields, vibration) may be problematic. It would be necessary to review each process with respect to potential emissions/exposures of the chemicals.

TABLE 1: ALUMINUM PRODUCTION: MATRIX OF HEALTH IMPACTS: BIOPHYSICAL ENVIRONMENT

Stressor/ Exposure	Nature of Stressor	Impact on Environment	Affected Area	Control Measures	Standards or Recommendations[2]
Technological Disaster	fires, explosions, spills, floods	toxic gases and liquids; destruction	site, perimeter, and vicinity	covering, containment, collection	CSA Z731-95, Emergency Planning for Industry
Gas Emissions or Emissions to Air	fluorides	vegetation dieback and decalcification in mammals	site, perimeter, and vicinity	scrubbers, new technologies, buffer zones	HF: 1.1 µg/m^3 (24-h EQG, CCME Canada)
	SO_2	acute chronic lesions on vegetation	regional (up to 100 km)	scrubbers, non-sulphur fuel	see NAAQOs (340 ppm 1- hr, 110 ppm 24- hr, 20 ppm annual
	CO_2	greenhouse effect	global	none, other than to modify the manufacturing process	none (compliance with international commitments)
	PAHs (anodes in particular)	air pollution	local, regional, and continental	collection, or modification of the manufacturing process	0.001 µg/m^3 for 87 excess cancers/million over 70 years (WHO-Europe)
Liquid Emissions or Emissions to Water	aluminum	toxicity to fish and aquatic insects	all pollutants: receiving watercourses	all pollutants in water: collection and treatment	none, operational targets between 100 and 200 µg/L
	fluorides	bioaccumulation in aquatic organisms			1.5 mg/L (MAC in Canada); 4.0 mg/L (U.S. EPA)
	dissolved organic matter and	unhealthy conditions, reduced visibility			500 mg/L (Canada, aesthetic objective)

	suspended solids				
	oil and grease	unhealthy conditions			none
	PAHs	neoplastic and genotoxic effects			0.01 µg/L (MAC, Canada, for benzo[a]pyrene)
Solid Emissions or Emissions to Soil	used potlinings	high toxicity	site	safe containment	solid pollutants: provincial regulations on waste or hazardous waste
	dross, grit, etc.	unhealthy conditions	site	recovery, recycling	
Nuisances	noise (fixed and mobile sources)		site and perimeter	noise abatement berm; buffer zone	L_{eq} 45 dBA (night) and 55 dbA (day) WHO guidelines

[1] Impacts evaluated in the current context, excluding old polluting technologies (e.g., anodes of the Soderberg type with horizontal studs). The analysis includes anode production (carbon plant), although this is a sector not found in all smelters, but excludes the production of alumina from bauxite, a process that normally takes place outside Quebec.

[2] CSA = Canadian Standards Association; MAC = maximum acceptable concentration; EQG = environmental quality guideline; CCME = Canadian Council of Ministers of the Environment; NAAQO = national ambient air quality objectives; L_{eq} = equivalent sound pressure level.

TABLE 2: ALUMINUM PRODUCTION[1]: MATRIX OF HEALTH IMPACTS: HEALTH COMPONENT

Stressor/ Exposure	Nature of Stressor	Effects on Health	Population at Risk	Probability of Occurrence	Biological/ Environmental Monitoring Indicators
Technological Disaster	fires, explosions, spills, floods	respiratory irritation, asphyxia, trauma, death	workers and immediate vicinity	very rare	morbidity/mortality reports
Gas Emissions or Emissions to Air	fluorides	eye and skin irritation, dental fluorosis, osteoarthritis	workers	rare to very rare	fluorides in ambient air
	SO_2	irritation of respiratory	probably none at theconcentrations	rare to very rare	SO_2 in ambient air

		mucosae	emitted		
	CO_2	climate change	global	frequent	concentration of atmospheric CO_2
	PAHs (anodes in particular)	types of cancer (mainly lung, bladder)	workers and local population	unknown	concentration of benzo[a]pyrene and other PAHs in ambient air
Liquid Emissions or Emissions to Water	aluminum	neurological problems	consumers of water from the receiving watercourse	unknown	aluminum concentration in the water
	fluorides	probably none at the concentrations found	same as above	unknown	fluoride concentration in the water
	dissolved organic matter and suspended solids	formation of THMs with chlorine in drinking water	same as above	very rare to frequent	visual inspection or suspended solids levels in the water
	oil and grease	unhealthy conditions	unknown	very rare	visual inspection or oil/grease levels in the water
	PAHs	types of cancer	consumers of water or aquatic organisms	unknown or very rare	concentration of various PAHs in the water and in wildlife
Solid Emissions or Emissions to Soil	used potlinings	high toxicity, irritation of skin and respiratory tract	primarily workers	very rare	accident reports on plant incidents
	dross, grit, etc.	irritation of upper respiratory tract	primarily workers	unknown	accident reports on plant incidents
Nuisances	noise (fixed and mobile sources)	sleep quality, stress	vicinity	occasional	complaints/perception

[1] Impacts evaluated in the current context, excluding old polluting technologies (e.g.anodes of the Soderberg type with horizontal studs). The analysis includes anode production (carbon plant), although this is a sector not found in all smelters but excludes the production of alumina from bauxite, a process that takes place outside Quebec.

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