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ENVIRONMENTAL IMPACT AND MANAGEMENT OF WASTES FROM PHOSPHATE FERTILIZER PLANTS

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ABSTRACT

The demand for phosphate fertilizers in India increased significantly during the Green revolution resulting in mushrooming growth of phosphatic fertilizer plants. The increase in the number of these industries has caused serious environmental problems due to release of toxic contaminants into air, water and soil. These industries have gained an ugly distinction as one of the worst polluting industries. The air emissions contain fluorides and SO2 along with heavy metals. Phosphogypsum, the major solid waste produced in these industries may contain trace metals and radionuclides. The liquid waste from these industries contains phosphates, fluorides and suspended solids. Inhalations of the toxic fumes from these industries cause autoimmune disorders, lung diseases, liver dysfunction etc. Phosphogypsum could contaminate surface and ground water sources. Large scale fluorosis and osteosarcoma in humans due to this contamination have been reported. Minimization of the environmental damage is possible by adoption and implementation of cleaner production processes, appropriate treatment technologies, bulk utilization of solid waste and following the standard emission guidelines.

INTRODUCTION

Rapid industrialization in India after the post independent era has often been associated with large scale ecological damage largely due to unscientific and unsystematic disposal of industrial effluents. Globally, fertilizer consumption has over the past few decades increasingly shifted towards developing countries. The main force responsible for the shift are the introduction of environmental legislation restricting use of fertilizer in many developed countries and a significant growth in fertilizer demand in developing regions as a result of an unprecedented growth in population particularly in Asia (Glasser, 1999b). Morocco in Africa is a leading producer and world's largest exporter of phosphate rock and phosphoric acid. In India, in order to fulfill the ever increasing demand for phosphate fertilizers in agriculture and allied fields, the number of fertilizer plants has increased many folds in last few decades. The increase in the number of these industries has caused serious environmental problems due to the release of toxic con-

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taminants into air, water and soil. Hence, phosphate fertilizer plants have of late gained an ugly distinction of one of the worst polluting industries.

Industry Description And Practices

Phosphate fertilizers are produced by adding acid to ground or pulverized phosphate rock. If sulphuric acid is used, single or normal phosphate (SSP) is produced, with a phosphorous content of 16–21% as phosphorous pentoxide (P_2O_5). If phosphoric acid is used to acidulate the phosphate rock, triple phosphate (TSP) is formed. TSP has a phosphorous content of 43-48% as P_2O_5. Phosphatic fertilizer complexes often have sulphuric acid and phosphoric acid production facilities. Sulphuric acid is produced by burning molten sulfur in air to produce SO_2 which is then catalytically converted to SO_3 for absorption in oleum. SO_2 can also be produced by roasting pyrite ore. Phosphoric acid is manufactured by adding sulphuric acid to phosphate rock. The reaction mixture is filtered to remove phosphogypsum, which is discharged to settling ponds or waste heaps.

Wastes from the industry

Air Emissions

Fluorides and dust are emitted to the air from grinders and pulverizers during processing of phosphate rocks and finished product handling. The mixture/reactor produce fumes that contain silicon tetra fluoride and hydrogen fluoride (Glasser, 1999b; Ana *et al*. 2005). A sulphuric acid plant has two principal air emissions, sulphur dioxide and acid mist. If pyrite ore is roasted, there will also be particulates in air emissions containing heavy metals such as cadmium, mercury and lead. Phosphoric acid plants generate dust and fumes containing hydrofluoric acid and silicon tetra fluoride Glasser, 1999a).

Solid Wastes

Phosphogypsum is the major kind of solid waste produced in phosphate fertilizer plants. This is produced at an approximate rate of about 5 tons per ton of phosphoric acid produced and is often disposed off as slurry to storage/settling pond or in form of waste heaps. If the plants are located near seas, the solid waste is disposed off in the sea water. Phosphogypsum contains trace metals, fluorides, radionuclides that generally are carried through from phosphate rocks. In plants where pyrite ores are used, the solid waste is generally pyrite residue which contains heavy metals such as zinc, copper, lead, cadmium, mercury and arsenic (Haridasan *et al*. 2001).

Liquid Effluents

Process water used for transport of waste should be returned to the fertilizer plant after the solids have settled out. However in many industries this is not practised and an effluent is generated which contain phosphates, fluorides and suspended solids.

Environmental impacts

In early predawn hours when the air is still and moist, phosphate fertilizer factories are often shrouded in an acidic haze. Temperature inversions form airy bubbles of noxious acidic fumes forming the acid mist. The lemony taste of sulphuric acid and hydrofluoric acid leaves the lips tingling with burning sensation. Nostrils too feel the stinging effect. The floating minute acid droplets when come in contact with eyes, cause burning and watering in eyes. Constant inhalation of the noxious smog causes choking and coughing. Uninterrupted exposure to these pollutants might lead to ailments such as autoimmune disorders, toxic myopathy, chronic obstructive lung diseases, chronic bronchitis, blood disorders, liver dysfunctions, polyarthiritis, swelling of feet and lower legs, cardiac problems, reactive depression and memory loss (Glasser, 1999b; Czarnowski *et al*. 2003). A survey in Florida in USA indicated that people living near phosphate fertilizer plants are twice as likely to develop lungs cancer and osteoblastic leukemia (Glasser, 1999b). Fluoride is a major contaminant in the fumes from phosphate fertilizer plants. The insidious problem with air borne fluorides is that they can be very reactive when come in contact with moisture. When inhaled many fluoride salts react with water and breakdown into hydrofluoric acid and a toxic component. Both of these could cause serious damages to lungs tissues. A study on impact of air pollution from phosphate fertilizer industry in Nigeria (Ana *et al*. 2005) indicated that mortality rate of factory workers is alarmingly high due to lethal exposure to toxic contaminants.

Phosphogypsum, the major solid waste from phosphate fertilizer industry is one of the major causes of radioactive pollution (Haridasan et al., 2001). Particulate matter discharged into the atmosphere is a major source of release of natural radioactivity surrounding the fertilizer plants (Righi *et al*. 2005). Phosphogypsum too contains significant quantity of fluorides in compound forms. There is a high probability of surface and ground water contamination by fluorides from

phosphogypsum heaps near the industry area. Czarnowski *et al*. (2003) reported significant amount of fluoride and cadmium in the urine of children living near a phosphate fertilizer plant in Gdansk, Poland. Uninterrupted consumption of fluoride contaminated water might cause dental fluorosis (Shekhar *et al*. 2006). Fluoride accumulates in bones and makes them more brittle and prone to fracture. People exposed to high doses of fluoride are likely to suffer from hip fracture at old ages. Fluoride might accumulate in pineal gland, thus lowering production of melatonin, an important regulatory hormone. There are serious concerns that fluoridation of drinking water might cause osteosarcoma in young men. Fluorides too can cause infertility in people with longer exposure. Langer and Gunther (2001) have reported that alkaline dust deposits from a phosphate fertilizer plant in Germany drastically reduced soil microbial biomass and enzyme activities, which are important parameters of soil fertility.

Pollution Prevention and Control

Environmental damage due to the contaminants present in the wastes from phosphate fertilizer industries can be minimized by adopting the following remedial measures.

a. Implementation of cleaner production processes

Adoption of pollution prevention measures can yield both economic and environmental benefits. Emission of SO_2 level into the atmosphere can be minimized by adopting double contact, double absorption process.

b. Treatment technologies

Scrubbers are used to remove fluorides and acid from air emissions. Treatment of effluents from scrubbers to precipitate fluoride, phosphorous and heavy metals can significantly reduce chances of environmental contamination.

c. Utilization of solid waste

Opportunities to use phosphogypsum, the major kind of solid waste as a soil conditioner for alkali soil and soils deficient in sulphur should be explored. This will help reducing volume of solid waste and save space for its disposal.

d. Emission guidelines

Well designed, well operated and well maintained pollution control systems help minimizing damages to the environment. The ideal air emission and effluent level should be achieved (Table 1 and 2).

Table 1. Air emissions from phosphate fertilizer plants (mg/L per cubic meter).

Pollutant	Maximum value
Fluorides	5
Particulate matter (pm)	50
SO_2 (sulphuric acid plant)	2 kg/ ton acid
SO_3	0.15 kg/ ton acid

Table 2. Effluents from phosphate fertilizer plants (mg/L per cubic meter, except pH)

Pollutant	Maximum value
pH	6-9
TSS	50
Phosphorous	5
Fluoride	20
Cadmium	0.1

Monitoring and Reporting

Fluoride and particulate emissions to the atmosphere should be monitored continuously. In sulphuric acid plants the level of SO_2 and acid mist should be carefully monitored. The pH values of effluents should be measured regularly. Other parameters could be monitored on a monthly basis. The data should be compared with operating standards and corrective measures be taken.

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