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Original Article

A Case Study on Industrial Waste Management of Madurai, India

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Abstract *— Industrial waste contains a diversity of impurities, and therefore, for this reason alone, its treatment constitutes a special task. Furthermore, the emission limits for industrial effluent are constantly being tightened up. Cottage, small and medium scale industries in developing countries account for a large share of employment and, in most cases, production. The recent growth of these classes of industries has been in response to high labour availability and low financial resources in most of these developing countries. Waste Management is the collection, transport, processing or disposal, managing and monitoring of waste materials. The term usually relates to materials produced by human activity, and the process is generally undertaken to reduce their effect on health, the environment or aesthetics. Despite requirements for pollution control measures, these wastes are generally dumped on land or discharged into water bodies without adequate treatment and thus become a large source of environmental pollution and health hazard. Typical Techniques of waste management are Waste Avoidance and Waste Minimisation - Landfills - Incineration - Deep Well Injection Effective Strategies: - The 4 R's Strategy - Industrial Symbiosis. The main objective of this study is to know the sources and types of raw materials of manufacturing industries, processes involved and types of wastes generated in manufacturing industries, management and impacts of these wastes on the Environment and Health. This study presents an overview of industrial waste management in Madurai city.*

Keywords *— Environmental pollution, Health hazard, Industrial symbiosis, Industrial waste, Waste management.*

I. INTRODUCTION

Environmental pollution is the major problem associated with rapid industrialisation, urbanisation and the rise in living standards of people. For developing countries, industrialisation was a must, and still, this activity very much demands to build self-reliant and uplifting nation's economy. However, industrialisation, on the other hand, has also caused serious problems relating to environmental pollution. Therefore, wastes seem to be a by-product of growth. Management of Industrial Waste is not the responsibility of local bodies. Industries generating waste have to manage such waste by themselves and are required to seek authorisations from respective State Pollution Control Boards (SPCBs) under relevant rules. Wastes are unwanted or unusable materials. Waste is any substance that is discarded after primary use, or it is worthless, defective and of no use. The term is often subjective (because what is waste to one need not necessarily be waste to another) and sometimes objectively inaccurate (for example, to send scrap metals to a landfill is to inaccurately classify them as waste because they are recyclable). Industrial waste is the waste produced by industrial activity, which includes any material that is rendered useless during a manufacturing process, such as that of factories, industries, mills, and mining operations. It has existed since the start of the Industrial Revolution. Some examples of industrial wastes are chemical solvents, paints, sandpaper, paper products, industrial by-products, metals, and radioactive wastes. The rapid trend of the industry and high technological progress are the main sources of the accumulation of hazardous materials.

II. INDUSTRIAL WASTES

Industrial waste refers to any discarded materials that are produced during the manufacturing and production processes of the different types of industries such as factories, mines, plants and mills.

In a broad sense, industrial wastes could be classified into two types.

1. Hazardous Industrial Waste
2. Non-hazardous industrial waste

A. Hazardous Industrial Waste

Hazardous wastes, which may be in solid, liquid or gaseous form, may cause danger to health or the environment, either alone or when in contact with other wastes. Various agencies have defined hazardous wastes in different ways, and as such, there is no uniformly accepted international definition so far. It is presumed that about 10 to

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15 percent of wastes produced by industries are hazardous, and the generation of hazardous wastes is increasing at the rate of 2 to 5 percent per year.

Hazardous industrial wastes in India can be categorized broadly into two categories.

- Hazardous wastes generated from various industries in India
- Hazardous industrial wastes imported into India from Western Countries for re-processing and recycling.

The following Table 1. Represents the Sources of Various Hazardous Wastes

Table 1. Sources of various hazardous wastes

Hazardous Waste Component	Source
Heavy Metals	
Arsenic	Mining, non-anthropogenic geochemical formation
Cadmium	Mining, fertilizer industry, battery waste
Chromium	Mining areas, Tanneries
Lead	Lead-acid battery smelters
Manganese	Mining areas
Mercury	Chlor-alkali industries, healthcare institutes
Nickel	Mining, metal refining
Hydrocarbons	
Benzene	Petrochemical industries, solvents
Vinyl chloride	Plastics
Pesticides	Insecticides
Organic chemicals	
Dioxins	Waste incineration, herbicides
PCBs	Fluorescent lights, e-waste, Hydraulic fluid

B. Non-Hazardous Industrial Waste

Non-hazardous or ordinary industrial waste is generated by industrial or commercial activities but is similar to household waste by its nature and composition. It is not toxic, presents no hazard and thus requires no special treatment.

In particular, it includes ordinary waste produced by companies, shopkeepers and tradespeople (paper, cardboard, wood, textiles, packaging, etc.). Due to its non-hazardous nature, this waste is often sorted and treated in the same facilities as household waste.

C. Areas of application of some important Industrial Wastes

S.No.	Waste	Areas of Application
1	Fly ash	i. Cement ii. Raw material in Ordinary Portland Cement(OPC) manufacture iii. Manufacture of oil well cement. iv. Making sintered fly ash light-weight aggregates. v. Cement/silicate bonded fly ash/clay binding bricks and insulating bricks. vi. Cellular concrete bricks and blocks, lime and cement fly ash concrete. vii. Precast fly ash concrete building units. viii. Structural fill for roads, construction on sites, Land reclamation etc. ix. As filler in mines, in bituminous concrete x. As plasticiser xi. As water reducer in concrete and sulphate resisting concrete xii. Amendment and stabilisation of soil.
2	Blast Furnace Slags	i. Manufacture of slag cement, super sulphated cement, metallurgical cement. ii. Non-Portland cement iii. Making expansive cement, oil well, coloured cement and high early strength cement. iv. In refractory and in ceramic assistant v. As a structural fill (air-cooled slag) vi. As aggregates in concrete
3	Ferro-Alloy and Other Metallurgical Slags	i. As structural fill ii. In making pozzolana metallurgical cement
4	By-product Gypsum	i. In the making of gypsum plaster, plasterboards and slotted tiles ii. Asset controller in the manufacture of portland cement iii. In the manufacture of expensive or non-shrinking cement, super sulphated and anhydrite cement iv. As mineralised v. Simultaneous manufacture of cement and sulphuric acid

5	Lime sludge	i. As a sweetener for lime in cement manufacture ii. Manufacture of lime pozzolana bricks/binders iii. For recycling in the parent industry iv. Manufacture of building lime v. Manufacture of masonry cement
6	Chromium sludge	i. As a raw material component in cement manufacture ii. Manufacture of coloured cement as a chromium-bearing material
7	Red Mud	i. As a corrective material ii. As a binder iii. Making construction blocks iv. As a cellular concrete additive v. Coloured composition for concrete vi. Making heavy clay products and red mud bricks vii. In the formation of aggregate viii. In making floor and all tiles ix. Red mud polymer door

D. Some Industrial Waste Management Techniques and Treatment Options

There are different methods of managing solid wastes. Proper solid waste management is an important and integral part of environmental conservation which should be observed by industries, individuals, and recognized agencies worldwide to keep the environment clean as well as reduce health and settlement issues. The following are some of the common methods:

a) Recycling or Recovery

Recycling or Recovery of resources is one of the common methods of solid waste management. Conventionally, these items are cleaned and processed before recycling. The process aims at reducing energy loss, reduction of landfills, and consumption of new material. Fig. 1 represents the R's of the waste management pyramid.

Fig. 1 R's of Waste management pyramid

b) Incineration

Incineration serves the dual purpose of reduction of both the toxicity and the volume of the waste, which is an important consideration when the disposal of wastes is finally destined for landfills. Most of the process wastes from chemical unit operations can very well be treated in properly designed incinerators.

c) Deep Well Injection

Deep Well Injection is a liquid waste disposal technology. This alternative uses injection wells to place treated or untreated liquid waste into geologic formations that have no potential to allow the migration of contaminants into potential potable water aquifers. A typical injection well consists of concentric pipes, which extend several thousand feet down from the surface level into highly saline, permeable injection zones that are confined vertically by impermeable strata. The outermost pipe or surface casing extends below the base of any underground sources of drinking water (USDW) and is cemented back to the surface to prevent contamination of the USDW.

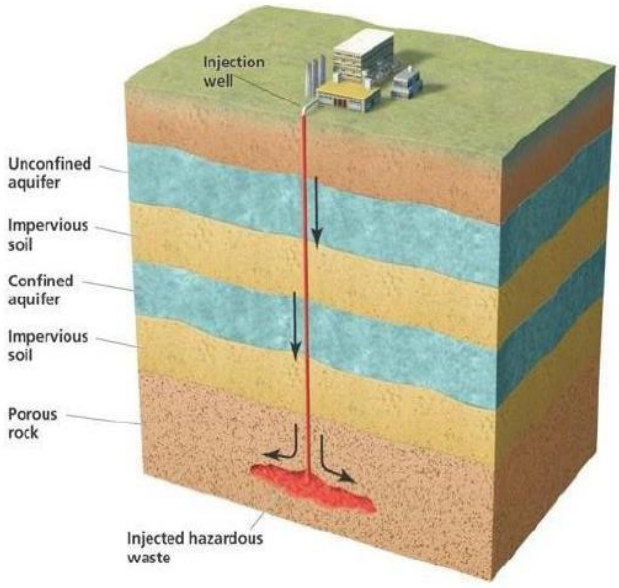

Fig. 2 Deep Well Injection

d) Laser Cleaning

Laser Cleaning uses high-energy laser beams to irradiate surfaces and instantaneously peel or evaporate rust, dirt and other unwanted substances.

Quite unlike ultrasonic, chemical, or traditional mechanical cleaning processes, laser cleaning doesn't require the use of CFC-based organic solvent, most of which cause significant damage to the environment and the ozone layer. This is one thing that you need to reflect on if you are trying to make your business more environmentally friendly. Laser cleaning tops the list of green cleaning processes. Fig. 3 represents the laser cleaning method.

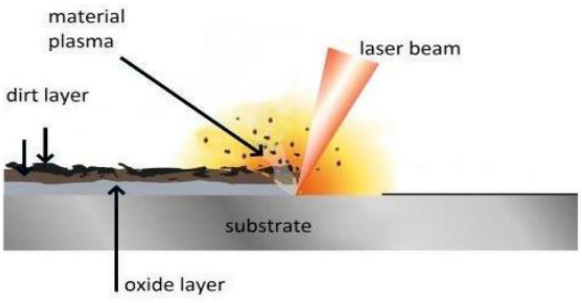

Fig. 3 Laser cleaning

e) Hazardous Waste Landfill

Hazardous Waste Landfill site is designed scientifically to have an impervious stratum at the bottom to stop leachates percolation and thus to avoid soil and water pollution/contamination in the vicinity of the landfill site. HDPE lining is used in making the landfill impervious. There are arrangements made for the collection and treatment of leachates from hazardous wastes.

f) Composting

Composting, Owing to the lack of sufficient space for landfills, the biodegradable yard wastes are allowed to decompose in a medium designed for such purpose. Only biodegradable wastes are used in composting. Quality environmentally friendly manure is made from compost and is used for agricultural purposes. Composting is a good green method of waste management.

g) Use of Hazardous Wastes as Alternate Fuels

In the European Union, about 3 million tons of hazardous waste from cement works has been used as an alternate fuel. There are a large number of hazardous waste generating units located in India. 11,138 units have been given authorization by SPCBs under Hazardous Waste (Management and Handling) Rules, 2003, mostly for the temporary storage of hazardous wastes within the plant premises. In India, about 4.43 million tons of hazardous wastes are generated annually, out of which 71,833 tons are incinerable (as per the reports of SPCBs submitted to the Supreme Court of India). There is a need to explore the possibility of using such wastes by other industries.

III. STUDY AREA

Madurai District is situated in the South of Tamil Nadu state. It is bounded on the North by the districts of Dindigul, Thiruchirapalli and on the East by Sivagangai and on the West by Theni and South by Virudhunagar. As of the 2011 census, it was the third-largest Urban agglomeration in TamilNadu after Chennai and Coimbatore and the 44th most populated city in India. Located on the banks of River Vaigai, Madurai has been a major settlement for two millennia. It is often referred to as "Thoonga Nagaram", meaning "the city which never sleeps".

Fig. 4 Study Area

IV. LITERATURE REVIEW

Briga-Sáet al. (2013) investigated the potential of reusing textile wastes. They illustrated that it is an enormous source of secondary raw material that is not used but can be re-injected into the market.

According to Lo et al. (2012), there are a few case studies that explore how environmental management systems adoption could improve textiles firms' performance. For example, Fresner (1998) analyzed an Austrian textile mill and found that the adoption of ISO14001:2004 helps the firm to reduce solid waste production and thus its overall productivity.

Brito et al. (2008) find that firms that adopt ISO14000 improve their customer services and reduce costs, leading to eventual improvement in the overall performance of their supply chains.

According to Richa Yadav and Dr Kapila Kumar, Department of Biotechnology, Faculty of Engineering & Technology, Manav Rachna, The electronic industry is the world's largest and fastest-growing manufacturing industry in the world. The increasing "market penetration" in developing countries, "replacement market" in developed countries and "high obsolescence rate" of electrical and electronic goods make electrical and electronic waste (e-waste) one of the fastest-growing waste streams.

Dr Nasreldeen Gidam Elnagy Majmaah University has given the concept of Reduce, Reuse and Recycle is three tools for sustainable development. Sustainable development is a development that meets the need of the present without compromising the ability of the Future generation to meet their own needs. It is essential to find new sources, but we cannot generate new sources; optimization of the resources can be one of the remedial measures.

V. DATA COLLECTION

Data has been collected from seven different Industries. Details of like manufacturing materials, waste generated per year and recycling methods of the seven industries are as follows:

A. Rubber Industry

a) Manufacturing Materials

Bull Nozzle Seals, Cylinder gasket, Grommet, Oil seals, Rubber bushes, Rubber cylinder springs, etc.,

b) Waste Generated per Year

5750 tons per year

c) Recycling Methods

Reversion to base material and Conversion to Heat

B. Plastic Industry

a) Manufacturing Materials

Garbage Bag, Grow Bag, VCI Plastic Bag, Polythene Bag and Self Seal Bag etc.,

b) Waste Generated per Year

9670 tons per year

c) Recycling Methods

- Sorted by polymer type
- Shredded
- Washed
- Melted
- Pelletised
- Made into new products

C. Steel Industry

a) Manufacturing Materials

Stainless steel tubes, steel tubes, alloy steel tubes, seamless tubes, carbon steel tubes.

b) Waste Generated per Year

19000 tons per year

c) Recycling Methods

Incineration

D. Chemical Industry

a) Manufacturing Materials

Chemicals, acids, commercial chemicals, lab chemicals.

b) Waste Generated per Year

31448 tons per year

E. Plastic Industry

a) Manufacturing Materials

Buy Packaging Boxes, Packaging Boxes in bulk, Sweet Box Container- 500 Grams etc.

b) Waste Generated per Year

4330 tons per year

c) Recycling Methods

- Sorted by polymer type
- Shredded
- Washed
- Melted
- Pelletised
- Made into new products

F. Chemical Industry

a) Manufacturing Materials

Dyes, chemical dosing pump, de-scaling chemical, acetic acid, oxalic acid, soda ash, sodium hypo chloride, sulphuric acid.

b) Waste Generated per Year

11647 tons per year

G. Automobile Industry

a) Manufacturing Materials

Portable Diesel Engine etc. Buy Diesel Engine & Electric Locomotive Spares, Auto Maintenance in bulk.

b) Waste Generated per Year

25000 tons per year

Fig. 5 Shows Waste generation of Industries (Tons per day)

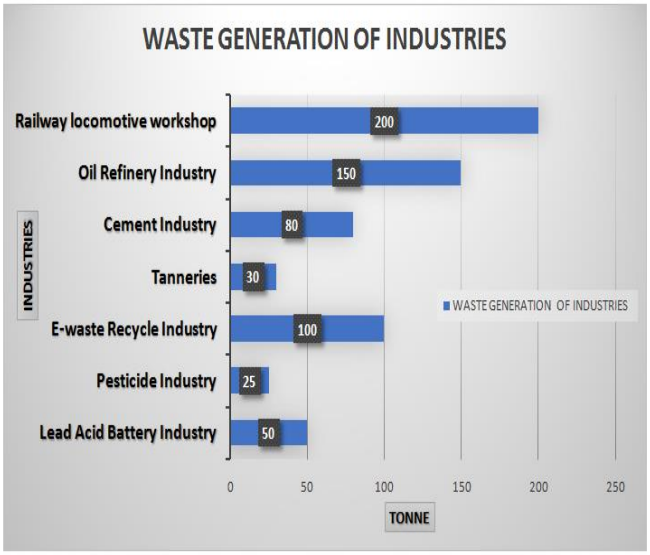

Fig. 5 Waste generation of industries (Tons per day)

Fig. 6 Shows Types of Pollution caused by Wastes

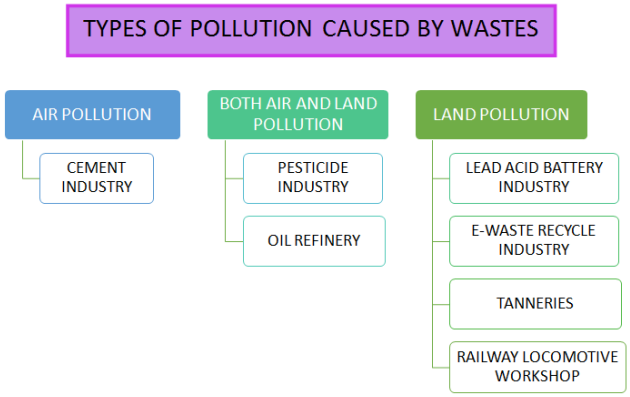

Fig. 6 Types of pollution caused by Wastes

Fig. 7 Shows Amount of Waste Received per Day

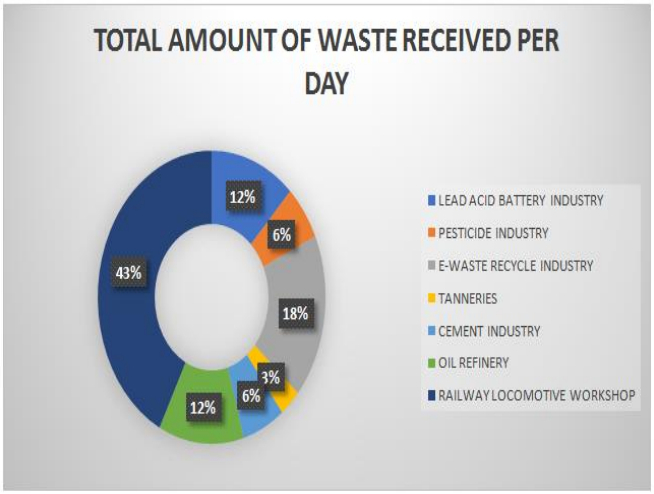

Fig. 7 Total amount of waste received per day

VI. CONCLUSION

Management of industrial solid wastes, which includes a wide range of hazardous pollutants. The largest amount of hazardous wastes were produced by plastics and chemicals, electronics, and nonmetallic minerals industries, respectively. Industries that produce the least amount of hazardous wastes are wood and cellulose, and paper. Results show that industrial waste management in this region was encountered major problems. These problems, due to the proximity of residential areas to the industrial unit, are of high importance and must be modified immediately.

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