POLLUTION CONTROL IN RECYCLING INDUSTRY

1. Introduction - Recycling industry frequently causes pollution to the environment. It is either the same or more than any other industrial activities. For example, paper recycling causes water pollution, which affect agricultural and fishery production. Refineries of metal scrap industry cause air and water pollution. Lead acid batteries recycling is a typical industry causing environmental pollution in developing countries.

When hazardous heavy metals are discharged to the environment, causes health damages. In fact, many small scale recycling industries without any pollution control mechanism exist in developing countries. Large production capacity recycling plants can afford to invest in pollution control equipment and hire technological experts to control pollution. It is easy for government to enforce pollution control regulation on big companies, which have financial and technological capacity to deal with the problem. It has been observed both in developed and developing countries that if the government strengthens the enforcement in small scale industries, it is possible that small scale industry migrate to remote areas, and carry out same business behind the wall.

It has also been observed that informal recyclers dominate the market of collected recyclable waste, because their cost of recycling is cheaper than that of formal recyclers. The competitiveness of informal recycler comes from non payment of taxes and no investment in pollution control. As a result, formal recycler with pollution control equipment and systems faces lack of recyclable waste, which becomes obstacle for the growth of formal recycler. This situation makes recycling industry as one of the most polluting industries in developing countries.

2. Pollution from Small and Medium Recycling Industries – The scrap recycling industry is growing at an exponential pace, specially in developing countries. The major source of raw material for this industry is recyclable scrap generated from municipal solid waste and domestic industry. The majority of recycling industry operates in medium to small scale unorganized sector without any pollution control. This results in uncontrolled emissions leading to environmental pollution. Therefore, it is pertinent to assess the structure of small to medium scale recycling industry, their recycling technologies used, and their pollution potential. At sector level, the recycling industry is generally, organized into paper, plastic, ferrous and non-ferrous sectors. In the non-ferrous sector, the majority of recycling industry is involved in zinc, copper and lead production. E-waste is a new waste stream, which provides raw material to the ferrous and non-ferrous recycling sector.

3. Processes and Technologies for Recycling and their pollution potential – Processes and technologies used in recycling sector ranges from advanced to very crude in nature.

a. Waste paper pulp is produced from two types of plants. The low quality of paper is produced by mechanically pulping the waste paper without chemical use. This pulp is used to produce brown paper and paper board. The good quality paper is produced by mechanical pulping followed by removal of inks/ pigments and bleaching. Most de- inking is done by 'washing' or floatation, or a combination of both the techniques. Washing is used to remove small particles of ink while flotation is used to remove ink particles which are too small to be removed by screens and cleaners but too big to be removed by washing. Both the processes involve the use of chemicals. The washing technique uses chemicals known as wetting agents and surfactants to detach ink particles from wastepaper. The particles are then removed through repeated washing. The floatation process is based on ink agglomeration chemistry. After the ink is detached from the wastepaper, the ink particles are made to stick together by using suitable collectors like fatty acid soap. The resulting slurry is then taken to a flotation cell where lime is added to make them hydrophobic (so that they do not dissolve in water). The ink particles then get attached to air bubbles passed through the slurry and are finally discharged as foam sludge. This process can handle both old newspapers as well as coated paper, which is used to print magazines. Starch and calcium carbonate are added to strengthen the pulp followed by blending with water to achieve proper pulp to water ratio. Alum, rosin, talc and acid are added to condition the paper before it is sent to paper machine, where steam is used for drying.

The major pollutants emitted from waste paper pulping are effluents and solid waste. Effluents are generated during pulping especially during de-inking, blending, conditioning and drying. Processing wastepaper generates sludge. In case the wastepaper is de-inked, the sludge contains heavy metals. Industrialized countries usually incinerate de-inking sludge. But in most of developing countries, most of it is disposed of in landfill or sold out.

b. Both consumer and industrial plastic waste generated is recycled. After sorting and cleaning, the plastic waste is grinded, cleaned and dried. After drying, it is agglomerated and further grinded. After grinding it is granulated and packaged.

Plastic recycling process generates fugitive dust, waste water on account of cleaning and solid waste. Since no chemical process/ burning is involved in plastic grinding and granulation, effluents have high suspended solids.

c. Small scale steel producers mostly use scrap-sponge iron-pig iron combination to produce steel ingots (for long products) using Electric Arc Furnace (EAF) or Induction Arc Furnace (IAF) route.

Though the units in steel sector are in small scale sector but quantity of pollutants generated by them is significant. The number of units in different clusters produces huge quantity of obnoxious fumes and discharge effluents without any pollution control devices, causing severe pollution in surrounding areas.

d. The majority of the secondary zinc units use both mechanical and electrolytic method while some units recover zinc from zinc ash by mechanical methods and sell fines (mainly 50-60percent zinc oxide) to zinc chemical manufacturers. Mostly, the raw material used for secondary zinc production by zinc recyclers is zinc ash/ skimming/ dross and steam blowing, which arises as a waste from domestic and imported galvanizing industry. Two types of dross namely top dross that floats on the top of the bath and the bottom dross that sinks to the bottom of the galvanizing bath based on the specific gravity of the material are obtained as raw material from the galvanizing industry. Zinc content in dross's lies in the range 90–96%. The technology followed to extract zinc is hydrometallurgical based involving leaching, metal purification, separation, precipitation and electrolysis. In some of the units, ZnO is manufactured from the secondary zinc following pyro-metallurgical processes, which involves carbon reduction and vaporization of zinc followed by controlled oxidation to produce ZnO. The process of zinc extraction from zinc ash consists of material preparation, leaching, purification, electrolysis/melting and bleeds off. Zinc ash is generally available in the form of lumps and chips. It is therefore, first crushed and then pulverized to separate out metallic zinc from fine ash. On melting and casting, metallic zinc is obtained. Fine ash is subjected to calcinations in oil fired rotary kiln at 9000C. Calcined ash lumps are pulverized again to get particle size of 100 mesh. The calcined fine ash is then treated with sulphuric acid and/or spent electrolyte generated during electrolysis for leaching operation. During this operation, compressed air and pyrolusite (MnO2) are added to oxidize ferrous ions to ferric ions. Leaching of zinc is continued till pH 4.5 to 5 where oxidized impurity of iron is hydrolyzed to ferric hydroxide precipitate. The clear solution of zinc sulphate is then sent for purification. In the first stage, copper is cemented out with addition of zinc dust/powder. The resultant pulp is filtered to remove copper as copper cement and filtrate to taken to second stage purification. In the second stage, solution is treated with Di-methyl Glycol (DMG) to remove impurity of nickel. In the third stage purification, activated charcoal is added to remove organic impurities. The purified solution mixed with spent electrolyte is electrolyzed using lead anodes and aluminum cathodes. Zinc metal deposits on cathode and oxygen is given off at anode and sulphuric acid is regenerated in the process. Deposited zinc is stripped off manually after every 24 hours and is melted in oil fired crucible furnace. Molten zinc metal is cast as zinc ingots. Spent acid is reused in the process. Bleed off, to lower down the impurities in the system some zinc sulphate is bled off time to time. This is used to manufacture zinc sulphate crystals.

Air and water pollution and solid waste management are the major issues in secondary zinc recovery units. Pollutant emissions take place from rotary kiln. Effluent discharge occurs during leaching, electrolysis and bleeds off. Waste is mostly in the form of residues, which are often disposed off in unsystematic landfills, though some industries follow the safe handling and disposal procedure laid down officially by monitoring agencies.

e. Copper recycling sector uses copper based industrial waste suitable for copper recovery through pyro-metallurgical and hydro-metallurgical processes. The choice of the process can be made on the basis of physical form, copper content, chemical nature, chemical composition and possible recovery process. These wastes include converter slag, anode slag, ETP (effluent treatment plants) sludge, anode slime etc. Wastes like dross, reverts etc. are best recycled by pyro-metallurgical process including melting, fire refining and electro-refining. The converter slag is also recycled using smelting furnace and precious metals like Ag and Au are recovered from the anode slime by using electrolysis. Other waste except for high grade mill scale can be recycled by hydrometallurgical processing, e.g., slag is subjected to copper recovery by flotation and the residual slag can be smelted in an electric arc furnace.

Most of the secondary copper units do not follow the proper processing technologies and discharge effluents in the surrounding environment, causing air, water and soil contamination. Pollutant emissions, which take place from the secondary copper recovery processes, are particulate matter, fugitive emissions, volatile organic compounds, hydrogen chloride gas, dioxins and chlorinated furans. Acidic effluents are discharged during electrolysis and bleed off. Solid wastes from secondary copper units in the form of residues, metal oxides, un-burnt insulation, products of incomplete combustion are often disposed off in unsystematic landfills, though some industries follow the safe handling and disposal procedure laid down officially by monitoring agencies.

f. Recycling of Lead Acid Battery is one of the most hazardous jobs. Since it became difficult to process lead in the plant due to public opposition, some informal operators used drums in stead of smelting furnace to heat batteries by propane to melt electrolyte lead to recover lead without any pollution control. They conducted such operations underground, in a most clandestine manner. Secondary lead refining process is a batch process based on traditional pyro- metallurgical methods. Batch refining is carried out in hemispherical vessel usually stirred to mix the reactants. The metal is held molten while reaction products float out and recovered from the surface. These systems typically have no pollution control system. However, lead of purity of 99.99percent is recovered in these units.

Some of the pollution related issues include air and water pollution and solid waste management. During the processing of spent lead-acid battery in backyard units, operations like breaking, crushing, screening, dry mixing etc. generate airborne lead dust which directly or indirectly enter into the human system and the surroundings of the working area. Effluent discharge occurs during battery treatment. Since lead is a very toxic material, disposal of the solid wastes from secondary lead production in the secured landfill is essential and mandatory.

g. Most of the waste/used oil re-refining units in the small scale sector use the acid-clay process. This process has the disadvantage of resulting in the generation of large quantities of hazardous and toxic acid sludge and clay contaminated with oil and heavy metals.

Since the informal waste/ used oil recycling occurs in small scale sector, they are a major source of environmental pollution. A large number of roadside garages drain used oils from automobile engines without any record of the next destination of such oils. Used motor oil is also burned, generally in inadequate equipped installations. Such operations produce large quantities of heavy metal emission particles, toxic gases (SO2, NOx, HCl) and residue products, which are ranked among the most toxic in comparison with other environmental particles.

h. There are more than twenty three processes, which generally are used for E-waste recycling. The outputs from these processes are electronic components, plastics, glass, ferrous and non ferrous metals including precious metals.

The processes used by unorganized sector are manual dismantling, chemical treatment to extract non ferrous and precious metals and open burning. These processes produce air emissions, which may include dioxins due to open burning of plastics, highly acidic liquid effluents containing heavy metals due to chemical treatment to extract non ferrous metals and hazardous solid waste left after burning and chemical treatment of E-waste.

4. Measures to Control Pollution – Experience in developed countries regarding policy measures in controlling pollution from recycling industry showed the importance of enforcement of the regulations. In developing countries recyclers should follow strict regulations including air and water pollution control along with enforcement of the regulation should be strong enough to implement them effectively. In general, adoption of regulations and rigorous enforcement thereof are to be carried out in a manner prompted by individual pollution disputes.

If the intention to comply with the regulation is ensured by enforcement of regulations then the awareness of recyclers, information of pollution control technology including end-of-pipe technology and cleaner production technology should be provided by public authority or experts. Otherwise, they can not choose environmentally sound technology. Since such technology is expensive, recyclers may not afford installing pollution control equipment. If possible, low interest loan should be provided to small scale recyclers through industry associations, which can act as financial intermediary and a vehicle to disseminate information on the risks of pollution, the technologies and the financial options.

5. Conclusion – Recycling is considered to be good for the environment. But some material recycling processes cause environmental pollution, if proper pollution control measures are not applied. Relocation of the factory without any pollution control does not provide solution to the problem. If recycling plant is willing to invest in pollution control, information of pollution control technologies should be provided. If possible, financial support such as low interest loan can promote such investment.

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