Life Cycle Study of Plastic Waste

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by

Shyamala Krishna (nee) Mani

School of Environmental Sciences

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PVC TAPES
AND
DUMMY CORES
KIRTINAGAR

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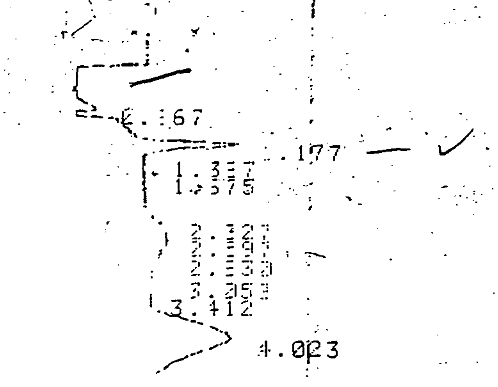

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10 PEAKS

जवाहरलाल नेहरू विश्वविद्यालय
JAWAHARLAL NEHRU UNIVERSITY
NEW DELHI - 110067

School of Environmental Sciences

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Certificate

It is certified that work embodied in this dissertation titled "Life Cycle Study of Plastic Waste" has been carried out in the School of Environmental Sciences, Jawaharlal Nehru University, New Delhi. This work is original and has not been submitted in part or in full for any other degree or diploma in this or any other University.

Shyamala Krishna
Candidate
(Shyamala Krishna nee Mani)

Prof.D.K.Banerjee
(Supervisor)

Prof.P.S.Ramakrishnan
(Dean)

GRAM : JAYENU TEL : 667676, 667557 TELEX : 031-73167 JNU IN FAX : 91-011-6865886

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INTRODUCTION

Life cycle study or Life cycle analysis of any product, examines every stage of that product's life. Environmental life cycle analysis is the name given to a cocktail of complex studies tracking the course of a product from its first manufacture to the end of its usefulness and measuring the environmental costs at all stages. As such, it is a decision - support system to help determine the products' environmental effects (Geschwinelt & Ward, 1993).

Life Cycle Analysis or LCA as it is known in short consists of three basic parts :

i) inventory analysis,

ii) risk assessment and

iii) improvements

While inventory analysis involves collection of data and analysis of the natural resource requirements and environmental emission quantities, impact assessment quantifies the actual harm to human health and the environment produced by the resource use and environmental emissions measured by the inventory. This addresses depletion of various resources, as well as risk to human health and to ecosystems of the many different pollutants and solid waste.

Thus LCA helps to understand the nature of the problem and suggest measures for reducing the environmental impact of a product or its waste.

The term 'plastics ' describes the compound based on a plastic type of polymer and the additives (Powell, 1983). There is a wide range of natural and synthetic polymers. Natural polymers exist in plants and animals and include starch, proteins, lignin, cellulose, collagen, silk and natural rubber. Synthetic polymers derive mainly from oil - based (petroleum) products and include polyethylene, nylon, epoxies, phenolics, synthetic 'natural rubber' and styrene butadiene rubber. Polymers form the basis of plastics, rubbers, fibres, adhesives and paints. There could be linear and network polymers which may be thermoplastic, thermosetting or crosslinked which again may be amorphous or crystalline (Powell, 1983).

Special feature's of Plastics :

Plastics are characterised by some typical qualities. They are :

Range of toughness : Some plastics are 'tough', eg. LDPE; some plastics are fragile , eg. general purpose polystyrene.

Temperature range : Some soft plastics just adhere. Amorphous plastics are not used above Tg ie the glass - rubber transition temperature.

Appearance : Amorphous plastics can be very transparent, partially crystalline ones can be translucent or opaque; colour plastics with dyes or pigments are opaque.

Degradability : Most plastics are not bio - degradable. It has been estimated that only about 10% of the plastics presently in use are bio - degradable (Raghupathy, 1994).

Insulation : In addition like other polymers, plastics have outstanding electrical insulation properties and hence exploited in wire covering and capacitor dielectrics . It also has limited thermal insulation properties.

Absorption : A few polymers can absorb some liquids causing swelling or even dissolution, accompanied by changes in physical properties, eg. PET (Polyethylene tetrapthalate) in molten condition is hydroscopic.

Dissolution : Like dissolves like, eg. hydrocarbon polymers such as polyethylene dissolves in hydrocarbon oils; many polymers resist acids and alkalis which corrode metals but some polymers are not oil resistant.

Burning : All polymers including polymers can be destroyed by flame or excessive heat, although the rate of destruction depends on the type of polymers, the surface to volume ratio, the temperature and the duration of exposure to heat. Comparable equivalents are :

cellulose nitrate	:	explosive
low density polyethylene	:	hard wax
PMMA (polymethyl methacrylate)	:	hardwood
polyethersulphone	:	only burns if flame is present
asbestos filled phenolic	:	used as ablation shield for spacecraft

Based on thermal properties, plastics are classified into thermoplastics (remouldable) and thermosets (non-remouldable). Important thermoplastics are, (alphabetically) acrylonitrile butadiene styrene (ABS), acetals, cellulose acetates, butyrates and propionate, ethyl-cellulose, fluorocarbons, polyamides (nylons), polycarbonate, polyethylene, polypropylene, polystyrene, and vinyls. As for thermosets, some are alkyls, allyls, caseine, epoxies, melamines, phenolics, polyesters, silicones, ureas and urethanes.

Plastics differ from each other in physical, chemical, mechanical, thermal and electrical properties. Many are made to suit required properties. Thus, a plastic raw material can be chosen for a particular application.

Commodity plastics are normally used for articles where technical requirements are either not critical or very low. Some of the common ones are low density polyethylene (LDPE) - transparent, flexible; linear low density polyethylene (LLDPE) - a little more transparent than LDPE but with better puncture resistance; high density polyethylene (HDPE) - translucent, more rigid than LDPE/ LLDPE, better moisture resistance; polypropylene (PP) - rigid, suitable for hinged applications; polystyrene (PS) - transparent, rigid, brittle; polyvinyl chloride (PVC) - fire retardant, good dielectric strength, (soft/rigid); MIPS (moderate impact polystyrene) - slightly better impact resistance than PS; and HIPS (high impact polystyrene) - good impact resistance.

Engineering plastics, on the other hand, are used for making components with high mechanical, thermal, electrical and chemical properties. They normally compete with conventional engineering materials like steel, aluminium, copper and brass. Common engineering plastics are : acrylonitrile butadiene styrene (ABS) - rigid, good impact/chemical resistance; polytetrafluoroethylene (PTFE); polyamide [nylon] (PA) - rigid, high temperature resistance, good barrier properties towards gases, high torque bearing capacity - ideal for gears/bushes; polycarbonate (PC) - transparent, rigid, exceptionally good impact resistance; polyethylene terephthalate (PET); poly-butylene terephthalate (PBT); ultra high molecular weight high density polyethylene (UHMW HDPE) and polyacetal.

Multilayer films are produced by the coextrusion technique where different types of plastic materials are simultaneously extruded from different extruders, but all come out from one die to give a single film with inseparable layers. These layers vary from two to five, depending on the machine. With this technique, it is possible to get a film with a combination of good qualities of all components. Packing in these films is becoming increasingly popular in the country. Common applications are vanaspathi, ghee and oil packing, snack foods, vacuum packing of meat, etc. (Durairaj, 1987,1989).

Plastics Waste - Sources and Options for Management:

There are two main sources of plastic wastes: manufacturers (ie. resin producers, fabricators, converters, assemblers, packagers, and distributors) and consumers of plastic products.

Manufacturers have recycled much of their uncontaminated waste for some time and this is now considered standard practice. However, there is a significant portion of manufacturing waste that is contaminated with other materials or is otherwise considered unsuitable for recycling. These wastes, which are often referred to as manufacturing nuisance plastics, have historically been disposed of by landfill or incineration. Historically, consumers have not recycled a significant portion of their plastic wastes. While a few postconsumer plastic materials have been diverted from the municipal waste stream because of, for example, bottle deposit laws, the vast majority of postconsumer plastics have been disposed of with other municipal wastes.

The first step toward either disposal or recycling is waste collection. The way in which waste is collected is very important because it is at this point that waste contamination can be avoided. If plastic wastes can be collected outside of the municipal waste stream, costly and technologically difficult separation processes required for most forms of recycling may not be necessary.

Once the waste is collected, the plastics can enter the conventional disposal stream (usually incineration or landfill) or be diverted to a recycling stream. In the case of landfill, the technological problems are not usually considered severe, at least with nontoxic and inert wastes such as plastics. The environmental problems of disposing plastics in landfills are more controversial and are either severe or insignificant, depending on the source cited. A consensus problem with landfill is, however, the decline in available land for landfill operations, especially around densely populated areas.

In case of incineration, plastic wastes pose environmental problems because of toxic fumes that may result from the burning of some resins. Technological problems may also arise because burning of some plastic materials such as PVC etc. may damage the incinerator. Further, in the case of incineration, noncombustible waste will be produced that is normally disposed by landfill.

While there are less costly disposal options, such as open dumping, those options can be ruled out because of their excessive environmental costs.

If recycling is selected, the first step is usually the separation of plastics from other waste materials. While the degree to which plastics must be separated depends on the particular recycling technology, separation, especially for plastics in the municipal waste stream, has been one of the problems that we have had to contend with.

Recycling technologies are ususally divided into four types : primary, secondary, tertiary and quarternary. Primary recycling is the processing of a waste into a product with characteristics similar to those of the original product. The recycling of relatively uncontaminated waste plastics, which has historically taken place in the manufacturing sector is an example of primary recycling. The current state of separation technologies does not permit the economical separation of plastics from a contaminated waste stream.

Secondary recycling is the processing of waste plastics into materials that have characteristics that are less demanding than those of the original plastic products. Some manufacturing and post consumer wastes currently enter secondary recycling streams, which allow higher contamination levels than primary recycling. Secondary processes usually produce products such as fenceposts and other bulky items that usually substitute for wood, concrete or metal.

Tertiary recycling involves the production of basic chemicals and fuels from plastic waste as part of the municipal waste stream or as a segregated waste. Pyrolysis and hydrolysis are examples of these processes. Tertiary recycling is currently taking place and is generating a great deal of interest mainly because relatively high levels of waste contamination can be accomodated.

Quarternary recycling attempts to retrieve the energy content of the waste by burning. In the case of plastics, this type of recycling can be very beneficial because of the high heat content of most plastics. While heating values of different resins vary from almost zero to over 20 000 Btus per pound, the average plastic contains about 12 000 Btus, or same as anthracite coal on a per pound basis (Curlee,1986).

Plastics Consumption, Waste and Recycling :

Plastics in India has been a postwar phenomenon, although the first plastic material "celluloid" was produced in 1862. Until 1940, the global production of plastics was about four hundred thousand tonnes. It went upto 10 million tonnes in 1962, and to over 100 million tonnes by 1992. The industry is expected to grow five per cent worldwide, almost five million tonnes per annum. In terms of value, the world plastics polymer industry has a turnover of over $ 100 to 130 billions (Anon, 1995).

India also produces basic polymers such as LDPE, HDPE, PVC, PP, PS and acrylics. However the demand has always outstripped local supplies and the industry has been largely dependent on the imports of polymers. The plastics raw material consumption in India during 1990 was a little over 900 000 tonnes and this was expected to exceed 1.5 million tonnes by 1995. By 2000, the demand will exceed 2.5 million tonnes. In spite of the rapid growth of the petrochemical industry in recent years, the demand - supply gap is likely to exceed a million tonnes by the end of this century. (ibid). The same article also says that the per capita consumption of plastics in India at present is 1.5kg which is very low, compared to the world average of 16 kgs but the approximate consumption of commodity plastics alone for the year 1993-94 was 12.30 million tonnes. The consumption of engineering plastics is expected to grow at more than 20% in the coming 5 years. The total consumption of major thermosets such as phenol formaldehyde, urea formaldehyde and melamine formaldehyde and unsaturated polyesters and epoxy resins was 50 kilotonnes before 1994 and is growing by over 10% per annum.. Plastics products have emerged as an important export commodity in the recent years and export earning from plastic products is expected to go upto Rs. 10,000 million in next 5 years (ibid).

Worldwide plastics use 4 % of commercially produced oil and contribute to 7% by weight (but almost 20% by volume) to the overall domestic waste (PWMI, undated). Plastic product consumption has been increasing steadily in India since 1964-65 and in the last 20 years it has gone up by 15% annually (The Economic Times, 1993). Percentage of plastic waste in the municipal solid waste in India has been going up too. For instance, a world bank study on 'Prospects for resource recovery from urban solid wastes in developing countries' published in 1982 shows a total absence of plastics in the composition of total solid waste stream in India. In yet another study funded by the World Bank and conducted by the Institute of Hygiene and Public Health, Calcutta between 1982 and 1990, the percentage of plastic, leather and rubber together has been shown to be less than 0.5% by weight of the total municipal solid waste, in municipal towns while in bigger metropolises and cities, it is 0.5 to 1.5%. Today, in a city like Bangalore with a population of 4.5 million, it can range from less than 1% in some low income residential areas to nearly 14.5% in industrial areas (Rao, 1990).

According to a preliminary study 'Energy from Bangalore garbage' (Rajabapaiah , 1988), percentage of plastics in garbage thrown into bins, before being picked by ragpickers was 6% while after some picking and at the dumpsite, it was 2%. It has been estimated that ragpickers in many cities in India pick out 15% of the recyclables - mostly dry waste including paper, board, plastic, glass, metal, rags, rubber etc. (Rajabapaiah , 1988; D'Souza, 1989; Venkateswaran , 1994). In a study done by Centre for Environment Education (CEE) in Bangalore, it was ascertained that various kinds of plastic waste which account for the maximum amount of discarded items (65%) collected by ragpickers , at an average rate of Rs. 8 per kg, also accounts for the maximum earnings in a day (88%).

The introduction of plastics in India was in the late sixties when a simultaneous approach for recycling was also adopted by the unorganised sector. In the initial stages, it was a cottage industry which utilised scrap cellulose acetate film and acrylic scrap for the bangle making. No attempts were made to qualify or quantify the plastic wastes that were being recycled, with the exception of the study conducted by the National Council forApplied Economic Research (NCAER) in 1988 which stated that in India, of the one million tonnes of plastics produced and imported per year, more than 0.3 million tonnes were being recycled in the 10000 (now 20 000) odd units all over the country where nearly 1000 (now 10 000) tonnes of different kinds of plastic waste reach every day for recycling. Plastic waste is being recycled and the products made out of these are both consumer as well as industrial items. There may be more than one stage of recycling in which case the quality of plastic has been seen to deteriorate after every stage of recycling (Malhotra, 1994).

It is now estimated that 1 - 2% of the municipal garbage in India comprises of plastic wastes (NEERI, 1988 and Ratra, 1995) which is comparatively a low percentage constituent of the waste compared to Europe and N.America where it ranges from 7 - 10% by weight (United Nations, 1992). Unlike the western countries where per capita consumption and waste generation is very high and reuse and recycling are astonishingly low at hardly 10% (ibid), in our country the case is of reverse nature, wherein per capita consumption is low and there is high rate of reuse and recycling. Although most plastics manufacturing industries carry out in - house recycling of industrial and process waste, (Sharma and Sundaresan, 1995) an estimated 1000 tonnes per month of polyester waste is dumped as scrap in municipal garbage. While in developed countries, processes have been developed to recycle polyester films, no attempts have been made in India. Also an estimated 1500 tons per year PET waste from packaging industry is dumped as scrap in municipal waste and not recycled in India.

Problems and Issues of Solid Waste Management in India

"It took the scare of Black Death, the pneumonic plague which hit Surat in September, 1994, to finally make people wake up to the connection between waste and health. For the unfortunate symbol of modern urban India today is a pile of rotting garbage." (The Hindu Survey of the Environment, 1995). This and other statements and articles on waste and related health problems are commonplace in the Indian press today. The concern is not only regarding 'rotting garbage' which as it suggests, refers to the biodegradable matter in the municipal garbage comprising 80 - 85% (CPCB, 1995) but also the non-biodegradable components comprising the rest of 15 -20% (CPCB, 1995). According to the Central Pollution Control Board, unregulated growth of urban areas, particularly over the last two decades, without infrastructural services and proper collection, transportation, treatment and disposal of solid wastes has led to increased pollution and health hazards.

Its report further categorises solid wastes arising from human and animal excreta as pathogenic while those from domestic, industrial and institutional having putrescible as well as toxic and hazardous substances and commercial waste having plenty of non-biodegradable wastes such as packaging, wrapping and throwaway food and beverage containers. "The problem of solid waste disposal, both from domestic and industrial sources, has become very acute in towns and cities as the development of disposal facilities has not kept pace with the quantum of generation of wastes" (ibid).

The following are some of the common causes, according to the CPCB, for indiscriminate disposal by industries and municipal bodies:

- Low priority for safe disposal;
- Lack of appropriate organisation;
- Lack of financial resources and technical manpower;
- Huge quantities of waste generated; and
- Lack of proper disposal sites and knowledge of disposal methodologies.

Since one of the conspicuous features of urbanisation in India is the skewed distribution of population with as much as 32.5% of the urban population in 23 metropolitan cities, a lot of garbage is generated in these cities. However, contrary to the opinion that congestion alone is responsible for the increasing solid wastes problems, the generation of garbage /capita/day in slums and low income areas can be as low as 150 - 200 gms. while in high income localities, the generation can be as high as 500 - 600gms/ capita/day (CEE South, 1994). In the words of Wesley E. Gilbertson, former Chief, Office of Solid Wastes, US Public Health Service, today the environment is being polluted, as never before, by the accumulation of solid wastes - staggering burden born of affluence, nurtured by rising populations, fostered by technology, and all but neglected by society.

Waste utilisation is essentially a preventive approach to environmental management which cannot be implemented in a reactive policy framework. Waste utilisation deals with two aspects, viz.,waste minimization and waste reclamation. The former involves consideration of the total cycle of production in an integrated and systematic manner to allow formulation of strategies for minimizing the generation of wastes. These may relate to raw material substitution, product reformation, equipment redesign and other low and non-waste technologies. Waste reclamation involves storage, collection, transportation and processing of wastes for recovery of reusable materials. Both strategies for waste utilisation achieve the twin benefit of conserving natural material and energy resources and circumventing environmental pollution. In addition, there are the advantages of employment generation, augmentation of basic necessities of life like food, shelter, clothing and fuel; increased profitability to industry; foreign exchange savings; and added foreign exchange earnings through higher and more value added benefits. Waste utilisation could thus contribute significantly towards sustainable development in a resource constrained economy as ours.The appalling conditions of uncollected garbage lying about on roadsides in most urban centres in India, is because, although, the collection and disposal of refuse is mainly labour intensive and the manpower provision for this activity in 75% of the towns, is 1000 - 3000 workers per million inhabitants, which is very low, but nevertheless it has been seen that cleanliness and promptness of service has no correlation with the number of workers provided and good results are obtained only when effective organisation and management is provided (Bhide, 1992).

According to the Planning Commission , (Government of India, 1995), health problems crop up due to improper collection, transportation and disposal of wastes, in most cities and towns in India. No doorstep collection facility exists nor bins at short distances are provided for community collection and disposal of wastes; as a results streets are treated as receptacles for waste. Neither are hazardous industrial and infectious hospital wastes collected and disposed separately. The current practice is to dispose off the waste by open dumping at the landfill sites which are generally low lying areas or dried up ponds and lakes. These pose a threat to health and environment; subsoil water contamination due to leachate is another potential problem in these dumping grounds. In places where composing is done in local bodies, the methodology adopted at most of the places is inefficient and unhygienic.

While commenting on the laws governing the collection and disposal of solid wastes in any place in India,(Bhide, 1992), it has been pointed out that public health and sanitation falls within the purview of state laws and most of the states like U.P., Punjab, Bihar, Tamil Nadu and West Bengal are governed by old laws passed in 1916, 1911, 1922, 1920 and 1932 respectively which deal with domestic and to some extent trade waste only and that too cursorily. Some of the problems such as presence of plastics or other polymers in the waste was not existent at those times and also the intensity and nature of problems due to improper handling and disposal of garbage was not perceived to be so severe. Hence they do not provide sufficient powers to civic authorities for prosecution of offenders with the result that enforcement becomes impossible in today's context.

In this connection, it is worthwhile examining the Himachal Pradesh Non-biodegradable Garbage (Control) Act 1995 which was passed by H.P. legislature earlier in 1996. This Act while clearly defining the terms 'biodegradable' garbage, spells out the polymers like "PVC, PP, PS, PE, Nylon and other plastic goods which are not capable of being destroyed by the action of living beings and prohibits any person by himself or through another knowingly or otherwise throw or cause to be thrown in any drain, ventilation shaft, pipe and fittings, connected with private or public drainage works, any non-biodegradable garbage or biodegradable garbage in a non-biodegradable bag or container likely to injure the drainage and sewage system; interfere with the freeflow or affect the treatment and disposal of drain and sewage contents, and be dangerous or cause a nuisance or be prejudicial to public health".

The problems discussed in the Act such as blocking of drainage by plastic bags, wrappings and other non-biodegradable articles is very common in other parts of India too especially in small towns where there are open drains and uncleared garbage dumps. In large cities too, with the practice of using more and more of non-biodegradable packagings for food and other items of daily use, roadsides, marketplaces and even housing colonies are seen to be strewn with disposable plastics. To add to this is the menace of a host of disposables from hospitals and clinics, mostly plastics, along with needles and other sharp objects, extremely infectious and contaminating every other thing on the road and a potential health hazard to anyone walking on or beside it. Although, by weight, plastics make up less than 5% of the total municipal solid waste, because of their lightness and low density, make up almost 15 -20 % by volume and if this is not managed properly can cause major disruptions in sewage and other underground and surface infrastructural systems.

The H.P. Act in the statement of objects and reasons spells out very clearly that the presence of polyethylene bags/pouches makes the growth of plants, microorganisms and numerous botanical species nearly impossible. "Rain water cannot percolate to the subsoils and leaching of harmful chemicals (particularly in low grade and recycled plastics) have led to unwarranted contamination of subsoil elements. Besides this, drainage system in hilly areas, has relatively smaller cross-section and any choking of drainage and sewage system due to polythene can lead to colossal damage and is likely to cause a nuisance or be prejudicial to public health." It goes on further to say that in other parts of the country, recycling has been considered as a solution to this menace but in hilly areas, a large fraction of garbage generated every day is thrown down steep inclines of the hill sides and there is no way in which this garbage can be collected by ragpickers for recycling. Thus, it has become necessary to prohibit throwing or deposit of plastic articles in the public drainage and sewage, and to facilitate the collection of said garbage or waste polythene material for recycling. This has been done by directing the local authority to provide separate bins and promote segregation at source through education (Government of Himachal Pradesh, 1996).

Plastics Wastes Recycling

The recycling of plastic wastes consists of collection, separation and processing. There are a number of steps involving each stage which are interdependent and strongly influenced by the nature of the waste. The steps are prioritised according to whether materials recycling, mechanical recycling, chemical or feedstock recycling or energy recovery through incineration is to be carried out.

Collection of plastics is the key activity to the whole recycling operation, because the ability to do this cost-effectively will increase the value of the final product. Collection systems are of three types (Baton, 1989)

i) Bring Back (Bottle Banks)

ii) Collect (Kerbside collection) and

iii) Centralised treatment

Bring back schemes require the consumer to return used items to a collection point such as Bottle Bank etc. The advantage of this system is that the consumer pre- sorts the waste and hence no contamination

Kerbside collection schemes are applied to the collection of waste - mostly domestic from designated containers at the kerbside. These schemes generally resulted in higher return rates than Bring Back schemes, but the level of contamination is higher too.

Centralised recovery systems are effective but lead to collection of more contaminated waste which require greater effort for sorting and cleaning the recovered material.

In India, the collection, separation and recycling of plastics, paper and other type of waste presents an altogether different but socially and technologically an interesting picture wherein the waste collection is a self-organised activity through a chain of ragpickers or waste collectors. dealers and reprocessors for whom this is a source of income. The plastic waste collection and reprocessing network is highly developed and as per one of the estimates in 1987 - 88 (NCAER and IPCL, 1988), India has been reprocessing around 37% of total available plastics and the trend has not changed in the recent past. In India, PVC content is reported to be highest - about

45%, followed by LDPE, HDPE, PP and styrenes and very small portion of other polymers (Malhotra, 1994).

There is no doubt that through thousands of ragpickers in every city and town in India, plastics and other non-biodegradable material to the extent of 15 to 20% are picked up from garbage and sewers and is being recycled every day and nearly 66% of this being plastics, a substantial quantity of plastics and other polymers are being removed from the environment. Besides these, householders, office and shop assistants and factory workers segregate and sell clean or almost clean domestic, commercial or institutional and industrial plastic waste which are easily recyclable and fetch very good scrap prices among traders who sell these to plastic recycling units in the various cities and towns. This is also the reason for low percentage of plastics at the site of disposal in most Indian cities except hilly and inaccessible areas.

Plastic Waste and Socioeconomic problems

As long as there is a significant gap between demand and supply of polymers and resins in the country, and the cost of locally available resins and compounds are as high as imported virgin material, and as long as there is an ever growing demand for cheap plastic items in the country by both and rural and urban people, many of whom are not accustomed to very high quality stuff anyway, plastics recycling in this low grade manner, using poor quality plastic waste (from gutters and garbage dumps), in low grade melters and extruders (most of which do not have temperature control mechanisms and many of which just char the plastics) and with low grade, toxic colours and additives, will go on. To add to this is our huge mass of extremely poor and destitute children. women and families who are totally dependent on waste picking for their livelihood, being illiterate, having no capital, collateral or skills to even run a small enterprise or survive by means of working for others. These ragpickers - 60% of whom are children, 30% women and only 10% men (among whom are old men and the disabled too), pick waste from garbage bins and dumpsites with bare hands and more often than not are pierced by needles and sharp objects and exposed to infectious microorganism and toxic chemicals besides fumes from burning garbage and polluted, stagnant water in and around garbage bins and dumpsites.

It is indeed well documented that workers in the municipality who handle garbage everyday, are affected by several kinds of ailments including respiratory, ophthalmic, skin, gastrointestinal and now other kinds of allergies and toxicity problems and infections hitherto not encountered (Government of India, 1995). Similarly ragpickers, who have no access to any protective gear or equipment while picking material from garbage expose themselves to virtually the whole gamut of infections from hospitals, and other medicare establishments besides handling toxics and hazardous substances from homes, hospitals, shops, offices, small industries and service establishments. In fact the sorters and workers in the small recycling units spread all over the city, are more exposed to toxic substances, effluents and fumes. Many of them are young boys and girls who are not even alive to tell their story. However, many ragpicker children who start on ragpicking at very young ages of even 5 and 6 although most of them start between 8 and 11 (CEE South, 1994 and Venkateswaran, 1994) succumb to infections and systemic disorders acquired from handling garbage since they, unlike adults are not aware of touching and sorting infected or toxic waste and are often used by unscrupulous traders in the waste sector because of their ignorance and low wages to pick and sort and handle extremely hazardous waste and chemicals. They are the short lived, one time use disposables of our society.

The waste (plastics inclusive) so collected is sold to agents who further employ more poor, immunocompromised, nutritionally poor destitute children, women and men to sort and sometimes 'clean' the waste by dusting, sometimes washing but most of the times as such sorted according to resin type and quality such as transparent, white or coloured and whether 'milk', 'alcohol', 'hospital' or just 'bottle' and baled for processing in units in machinery, manufactured and assembled locally. The reprocessing units may further have the plastic waste sorted, cleaned and removed of foreign matter and in one room sheds which are hardly sufficient to hold the grinder, blender, extruder, cutter etc., 4 to 5 men and women sort, clean, grind, blend and process the plastic waste thus prepared into agglomerates or pellets amongst stored waste plastic bought in bulk, chemicals, colours and additives and processed granules ready to be sold to traders in plastic resin and compound markets or coversion industries who convert the granules and agglomerates to cheap plastic products.

Pollution due to Plastics Waste Recycling

Many of the plastic sorting, cleaning and processing operations cause some kind of pollution - air, water or soil or all besides being hazardous to the health of the individual/s involved in the work. The plastic waste too, because of the way many of these are collected from gutters and garbage dumps (especially post-consumer waste), also because of the very nature of the plastic to become contaminated by chemical and oil based contaminants such as petroleum based oils, pesticides, paints, disinfectants and several others and because of their preference in medicare as disposables and for food and beverage packaging due to their lightness and impermeability, is a source of worry to any person who may inadvertently use a product made from such sources. Furthermore, the addition of toxic colours and additives during processing and the very method and machinery by which the compounds or granules are regenerated with no temperature control or precautionary measure to prevent the plastic from degrading, makes the compounds as well as the products made from these compounds, suspect and unsafe especially for reuse as packaging for food and water or beverages (Taneja et al, 1994 and Sharma et al, 1995). But that is exactly what is happening! Many of the products made of LDPE, HDPE, PP, PVC, and PS etc. which have been used for storing toxic chemicals, paints etc. are washed and sold in the market areas for reuse as storage for water. Similarly, recycled plastic granules especially LDPE, HDPE. PP etc. are not segregated according to the contamination they have acquired during their first life span as packaging for a particular material but after melting and regranulation are made into cheap products for storing food, water, beverages and even healthcare products such as chyawanprash etc. wherein even after washing, the contaminants remain due to physical penetration of the toxic molecules and priciples into the plastics and leache out when other substances such as water or fat are stored in it (Poll, 1995).

Aim of the Study :

The aim of this study is to investigate the life cycle of plastic waste in an urban situation especially the source of the waste from where it was picked up, its possible route and contamination, its subsequent reuse where again it may pick up some contamination before being sent for reprocessing. This in itself is not without risks, polluting air, water, soil and resulting in granules and products of dubious quality. Specific indoor air quality parameters were to be assessed in some selected units representative of the different types of reprocessing activities. In the processing units, air quality parameters such as total and respirable particulate matter, SO_2 , CO and NO_x at the workplace would be determined so that an estimate of the occupational exposure to the workers can be made. In case of PVC units, HCl, Vinyl chloride monomer, lead and cadmium and in PS recycling units, styrene was also to be assessed. Based on these observations and analytical results, as also on the basis of direct observations on the workers' socioeconomic conditions, it was proposed to suggest some regulations for plastic wastes recycling in our country.

LITERATURE REVIEW

Issues and problems of Solid Waste Management

The World Health Organisation (WHO) is becoming increasingly concerned about the serious implications for health of the wastes management problem now facing developing, as well as more industrialised countries. The rapid growth in the world population density as a result of urbanization, industrialisation and technological development is making the satisfactory management of liquid and solid wastes, a vast and complicated problem. Down through the Middle Ages, slops thrown from doorways and windows were a constant hazard to town dwellers, many of whom succumbed to the pestilences spread by garbage - fed rats, flies and other vectors of disease. But today, the environment is being polluted, as never before, by the accumulation of solid wastes - a staggering burden born of affluence, nurtured by rising populations, fostered by technology, and all but neglected by society (WHO, 1969). Garbage in developing countries or where use of fresh fruits and vegetables is common, has a high content of fermentable matter nearly (80 -85%) of low calorific value, high moisture content, and high density. Therefore, it appears that the best option for utilization of city garbage produced especially from large vegetable and fruit market places, homes, gardens and commercial establishments is to produce energy through biogas and use the residue as manure. The technology for production of biogas and utilisation of residue as valuable manure is already well established in the country. However, a potential for biogas production must be established. (Rajabapaiah , 1988).

Waste utitlisation requires coordination between different interest groups such as primary waste producer, waste collecting agency and waste reclamation industry. Clearly, waste utilization is favoured only when there is economic incentive to recover materials; where these materials are available in pre-separated, concentrated and relatively uncontaminated form; and where materials have a high inherent value and costs of collection and processing are relatively low (NEERI, 1988). Instead, command and control regulations that deal with "end-of -pipe" pollution, have given rise to a sizeable pollution control industry that help industry to cope with the increasing numbers of environmental regulations. Even in the U.S., only after Love Canal, the community in New York that had to be evacuated because of severe health problems and deaths attributed to toxic waste in 1976, the nation's EPA (Environmental Protection Agency) agreed that waste reduction - not generating pollutants in the first place, should be the preferred option for waste management rather than land disposal or waste incineration or any other. Both treatment and disposal are vulnerable to the failure of technology, people and institutions. Furthermore, both treatment and disposal hold the risk of releases of hazardous substances, with uncertain effects on health and the environment. Thus, environmental protection system must move towards relying more on prevention and less on reaction to environmental hazards. (Hirschhorn, 1988).

Solid Waste Management in Indian cities is in a sorry state. Land disposal is the commonest method used, though in some cases, marshy lands are being filled up and reclaimed. Most of the towns operate at least one land disposal site, though in some metropolitan cities, multiple sites are preferred. Unfortunately, majority of landfill sites are only dumps where the waste is used to fill low lying areas and no specific precautions are taken with the result that pollution of surface and ground water by leachate commonly occurs. Industrial solid wastes, many of them hazardous are often disposed off at such sites as no specific controls are exercised on disposal (Bhide , 1992). Nearer home in Delhi, the Wazirpur Industrial Area is a virtual garbage dump. Garbage is not lifted from the area's dumps and roads for months (Indian Express, 1991). Same is the case with several areas in Delhi.

Therefore, with the constant urbanisation and industrialisation around the world, and limitations placed on landfill areas, both in terms of availability and cost of labour and transport, there have been pressures and counter pressures on Governments and local municipalities to set targets for recycling and reusing the contents selectively from domestic, commercial, institutional and industrial sources. In advanced countries, the extent of recycling is decided by two main factors. One is the cost of collection, the other is the disinclination of the public to use recycled material. This is because of the subsidy in these countries for raw material extraction which was introduced to encourage exploration and development, which is now making products made from virgin material cheaper than recycled products, the cost of collection being very high (Ratra, 1992).

On the other hand, India and many other South Asian countries have to import most of their petroleum requirement at very high cost and so also virgin polymers to fulfill basic demand. Cost of products made of virgin material is not low. Besides, due to poverty and destitution, there are several thousand 'ragpickers' and 'kabadiwalas' all over the country who do the job of 'collection' at almost no cost and sell it to agents or waste collection points from where it is sold to wholesalers and reprocessing units. These reprocessing units, although not fitted with sophisticated devices and neither being automated, are labour intensive but in the whole of South Asia, labour being cheap, it provides employment while reducing processing cost. Therefore, the cost of recycled granules as well as products are almost 50% of the cost of products made from virgin material. The percentage of recycling of paper, plastic etc. in India is more than 40% but this also raises certain major environmental issues (Krishna, 1992).

In most developed countries, solid waste management still follows the traditional routes of landfill, burning etc. Some of the countries have begun composting to the extent of 5 - 10 %. In Austria, composting is 37% by weight. Only Japan has been able achieve 50% recycling by weight while in U.S. it is 10% and U.K 3%. In all these countries, percentage of paper, plastic, glass and metal in garbage, by weight is > 20, 7, 10 and 8 respectively(Carr-Harris, 1992). There has also been an increase in packaging waste in the weekly dustbin with larger increases in volume rather than weight . This increase in packaging waste has come from changes in consumer habits. Formerly, the consumer prepared foodstuffs etc. at home. Modern society now dictates very different lifestyles and rhythms (Cooper, 1992).

Plastics Waste recycling

The effect of the processing operation on the photolytic stability of plastics has been reviewed and its implications for the reprocessing of contaminated mixed domestic waste plastics discussed (Scott, 1976). Samples taken include detergent, sanitary fluid and bleach containers from domestic sources and agricultural and industrial packaging films. It is concluded that if reprocessed products are to have adequate environmental stability, the development of effective metal deactivators, photostabilisers will be necessary. The merits of the alternative biological recycling processes involving incineration and biodegradation of plastics are compared favourably with materials recycling (Scott , 1976).

In the U.K, about 2 million tonnes of plastics are produced each year and of this only about 2.5 % to 3% is recycled. In some European countries like Germany and Austria, this proportion is much higher. In Japan, where the plastics content of household refuse reaches 10%, there is much interest in it as a new resource. In the Third World, especially the newly industrialised countries, there is considerable reuse and recycling ranging from scavenging on tips to industrial processes.

But with increasing use of specialist polymers, mixed polymers types and plastic - metal combinations, these products have not been designed for recycling.

By far the largest quantity of scrap, the most visible, and the most problematic is domestic waste, of which there is approximately 3/4 million tonnes per annum globally. On an average, each British household throws away a kilo of plastics each week, most of it in packaging or containers. This constitutes around 4 % by weight of British domestic rubbish (and more by volume). The proportion is higher in the U.S., France and Japan and it is expected to reach 9% by the end of this century. This plastic fraction is potentially valuable, but virtually none is recycled due to the immense and still unsolved problems of collection and separation. In Germany, environmental legislation prevents plastic disposal by burning or tipping and in France, an agreement has been reached to reduce packaging by 40% over 5 years. The key to acceptable recycling of homogeneous plastics lies in removing contraries, cleaning away contamination and separation into original polymers where possible. A first step is the increasing development of washing and drying plants to remove contamination. For sometime , recyclers had to use machinery from a variety of sources for reprocessing, sometimes running into problems of overheating the plastics. Simply regranulating the scrap plastics increases its value somewhat, but this may be doubled by extruding and pelletising (Bollard et al, 1982).

Packaging represents about a third of all plastics produced and public reclamation schemes depend on it. Although, Britain still salvages only a few hundred of the 1.3 million tonnes of packaging consumed each year, there are now at least 130 bottle banks for plastics and this figure will treble or quadruple by the end of 1991. At least 60 companies in Britain, another 300 across Western Europe and 600 in Japan specialise in recycling plastics. Most of these companies make granules out of clean, single polymer. The 60 British firms salvage only 50 000 tonnes (10 per cent) of polyethylene film production for recycling into black refuse film production or builders' sheeting. At least 25 000 tonnes (around 7 per cent) of annual polypropylene production is recycled each year. More than 70% of this salvage comes from bottle crates or car batteries and return to life in a similar product. There are more good, economic and technical reasons against recycling plastics than there are for it. However environmental pressure and the prospect of much tougher legislation to encourage reclamation have forced the industry to continue its development of recycling processes. Collection and sorting into various polymer types increases the cost of recycling. Plastic waste is hand sorted because prototype machines are slower and less accurate than people at separating old bottles and containers into streams of PET, PVC or polyolefins (Bell J., !990).

In the late 1970s, Eduard Klobbie, a Dutch engineer, decided to sidestep the problem of sorting and cleaning waste. He developed a process that melts dirty mixtures of plastics and injects them into moulds to form simple, sturdy shapes suitable as posts or planking. The Klobbie process uses waste plastics that contain at least 65 % polyolefins to act as a kind of adhesive. The rest of the feedstock consists of polymers such as polycarbonate, compacted granules of PET fibres and no more than a small proportion of PVC. Upto 5% of the feedstock can be impurities such as metal, wood or paper. As far as possible, the operator sorts the incoming waste by colour and polymer before granulating it. The aim is to build up stocks of known material, such as broken beer crates, substandard goods or contaminated compounds to mix with household waste and additives. Although the Klobbie process tolerates impurities, finished products that contain a high proportion of low density polyethylene, for example tend to be elastic. Similarly, high proportions of polypropylene in the melt lead to brittle articles. Horizontal mixers blend the different polymers to produce a reasonably homogeneous mix of granules. The mix then passes to an extruder, a rotating steel screw inside a steel barrel. Friction melts the mix inside the barrel as the screw extrudes the melt into a horizontal mould. The mould is one of 10 on a carousel that turns in a bath of water. As the top mould fills, others cool in the water, shrinking the mouldings inside before ejection. Mouldings from the Klobbie process can be upto 4 metres long, 12 to 50 mm in diameter and upto 125 by 125 mm in cross section. They resist rot and can be sawn, planed, nailed or painted just like wood. These properties make the moulding suitable for road signs, fencing, pallets or slatted floors for animal pens. No one has yet explained how to recycle these mouldings and there is a limit to the world's need for pigsties made of mixed plastics. However, there are other ways to make dissimilar polymers work together in a blend by adding compatibilisers etc. (ibid.).

What surely must be the smallest and cheapest injection moulding machine in the world is at work in Bangladesh. It can operate with 100% reclaimed plastic granulate as feedstock and can produce the tiny plug for the end of a ball point pen in 20 seconds, although it only produces one at a time. These machines demonstrate some fundamental features of the economy of

Bangladesh, well known as one of the world's poorest countries. Extremely low labour costs contribute to the fact that equipment costs around a fifth of the price found in almost any country in the world. Serious and effective import controls give an enormous boost to local manufacturers particularly those who use locally obtainable raw materials. A huge labour force of unskilled but highly enterprising Bengali people provides a massive market for anyone who produces low cost equipment which can be used by self-employed entrepreneurs to manufacture any product suitable for sale to the country's huge population (90 million). The same influences mean human rather than mechanized power will be economical and therefore, will be an attractive feature for manufacturing machinery (Vogler, 1986).

Furthermore, processing technologies are defined primarily by the purity of their required input streams and the quality of their products. As has been noted, homogeneous inputs are required for technologies that can use recycled plastics in blends with virgin resins or that can produce products competetive with products manufactured from virgin resins. As input quality falls, output products tend not to displace consumption of virgin plastics but to compete in markets with lower value commodities such as lumber and concrete.

The products of tertiary recycling processes (monomers and oligomers resulting from the nearly complete breakdown of plastics resins) do not compete with plastics strictly defined, but with the raw input materials to plastics (and other chemical) production processes (USEPA, 1990).

Summary of key findings regarding landfilling, incineration are:

Plastic waste, which represents a growing share of total waste volume, contributes to the rate of capacity use of landfill. Buried plastic wastes compress in landfills to a greater extent than had been understood, reducing the share of landfill capacity relative to that which would be needed were plastics to retain their shape. Plastic wastes are very slow to degrade in landfills but even other material such as paper and sandwitches are slow to degrade in landfills or dumpsites. Plastic wastes do not create difficulties for landfill operation. Analysis of leachate from monitoring of MSW (Mixed solid waste) landfills has detected organic chemicals such as are used as plasticizers, one widely used plasticizer, di (2 - ethyl hexyl) phthalate, has been detected in a number of leachate analyses at a range of concentrations. This additive could have originated in discarded plastic products in MSW.

Although the plastics contribute only about 7% by weight to MSW, they may contribute 15% or more to the total Btu content of MSW. Hydrogen chloride gas is emitted during combustion of PVC or other chlorinated polymers also from paper and food wastes. Dioxins and Furans from municipal waste combustors have PVC as the principal donor. Products of incomplete combustion under suboptimal operating conditions, all organic constituents of MSW (including plastics, wood, paper, food wastes, yard wastes and others) may release toxic products of incomplete combustion. Plastics ash contributes proportionately less to volume of incinerator ash. Lead and cadmium based plastic additives contributes to the toxic heavy metal content of MWC ash (ibid).

Recycling of scrap and production of end products from cheaper recycled resins saves raw material costs. Denmark has introduced mandatory deposits on all beverage bottles and Germany has a similar measure on plastic bottles. The European Commission has challenged these regulations as discriminatory to products of other member countries. Italy has levied taxes on plastics packaging and also banned nondegradable shopping bags. The German Bundestag voted against a ban on PVC in part because of industry's plans to recycle it. Other countries control indirectly the quantities of plastics in municipal wastes. France, the Netherlands, U.K. have voluntary agreements to maintain high levels of use of refillable containers and to promote recycling. Canada and the U.S. seek primarily to promote recycling and reduce litter and the volume of waste. The individual states and provinces largely regulate packaging. Only questions of health and safety are controlled by the federal governments.

Collection :

The Flemish Waste Management Association has experimented with container park for plastics and glass in Belgium and the Study Group for Modern Packaging has tried them (and other methods) in France, particularly for PVC water bottles. However, participation by householders is low - only about 20% in U.S. experience. In North America, curbside collection is by far the preferred method. Many municipalities provide each householder with a small bin for glass, metal and plastics recyclables. With proper organisation and good publicity, to enlist wide support, these programmes get broad participation - upto 90% in exceptional cases. Such programmes are rapidly growing and are said to reach 16% of the total U.S. population. In Canada, 7 out of 10 provinces have some curbside collection. Ontario, the most populous had programmes serving 62% of its population in June 1990. In Italy, reverse vending machines at supermarkets accept and crush plastic bottles. LDPE shopping bags returned to supermarkets; EPS packaging materials and PS coat hangers from factories and stores; PS trays, cups and utensils at school cafeterias and fast-food outlets; and PP cases from automotive battery breakers.

Sorting :

Although equipment is available for sorting mixed containers, only steel cans and aluminium and glass containers are separated by gravity, magnet etc. Mixed plastic stream is separated by hand into three fractions HDPE milk jugs, which are chipped and boxed for sale as is to processors; PET soda bottles which are crushed, perforated, baled and sold to recyclers; and all other containers, which are now sent mostly to incinerators or landfills, but can be used as feedstock for comingled plastics.

Processing:

After separation, traces of foods or beverages, paper and adhesives from labels, metal from bottle caps and other impurities are removed. The plastics are generally blended in large batches to assure uniformity before re-extrusion into pellets suitable for processing. Additives are incorporated to improve properties, particularly for engineering applications. Coloured resins such as green PETX are generally taken to darker applications. Gov't. agencies, waste management companies, or joint ventures ususally carry out the collecting and sorting. Resin producers then take over to process the recovered materials. Most, merely compound the recycle plastics and sell them to moulders and extruders but some make and market end products themselves.

Marketing :

Earlier, PVC received most attention for recycling in Europe because of its wide use in mineral water bottles and other packaging. Now because it is known that PVC emits toxic fumes on incineration, PVC is not much used in bottles. PET and HDPE are two principal resins recycled in North America. In addition, PP, PE film and PC are also recycled and marketed.

Commingled plastics :

After recovery of saleable resins, some plastics will always remain for disposal. The Plastics Recycling Foundation estimates that U.S. industry produces 500 000 metric tonnes of industrial scrap per year that cannot be used as regrind. Some of this material can be converted to "plastic lumber" for outdoor applications (Kirkman et al, 1991).

According to a recently released study (WWF and The Conservation Foundation, 1991) "all waste management practices, including recycling have associated economic and environmental costs and can simply shift pollution problem from one environmental medium to another". The study advocates source reduction as the best method for municipal waste reduction. " By reducing the amounts and toxicity of waste generated, a wide range of benefits can be realised". In particular, the report recommends evaluating processes and manufactured products according to a life- cycle assessment model that inventories the materials used, the energy consumed, and the pollution released; weighs the potential environmental effects from manufacture, and analyses changes needed to improve the product or process "environmentally".

To ensure that businesses and individuals adopt waste reduction, the study advocates a national policy with quantifiable goals drawn up by EPA for different regions and industries. Examples include encouraging individuals to compost yard wastes, conducting waste audits in businesses and industries, and encouraging double-sided photocopying in offices. Interestingly, the switch to plastics from glass and paper in products during the 1970s was promoted as a source reduction move because plastics require less energy to produce. As a product that also can be recycled, plastics could become the consumer material of choice (Newman , 1991).

An estimated 100 million tonnes of plastics are produced world wide each year. An average European family of four throws away around 40 kgs of plastics each year, which amounts to 7% of its total household waste by weight. Although plastics occupy an estimated 20 - 30% of the volume of the dustbin, 4% of oil is used in the manufacture of plastics - in Western Europe by comparison, 86% of oil production is used for transport, heat and energy in single-use and probably more wasteful applications. Only half the plastics purchased by householders are packaging and the remainder - plastic containers, toys, cassette cases etc. have an average five to ten years life span. To identify different types of plastics, some kind of marking is required. A numbering system first agreed in the U.S. is now being adopted in Europe. In Sweden, a colour code has been used. Reverse vending machines are in use which pay a small sum for each container deposited. If a bar code were used, it could even sort them. U.K. currently has 35 collection schemes handling 4 tonnes a week. In the USA, there are around 500 kerbside collection schemes which include plastics. Technology is becoming available to sort plastics electronically, by floatation and X-ray. Outlets for recycled plastics packaging materials include for eg. PE films for dustbin liners, PVC sewer pipes and flooring, PET fibres and audio cassette cases (The Warmer Campaign, 1992).

The most intractable problem relating to plastics and the environment is their disposal. Plastics are disposed of by landfill or burnring, generally as part of MSW. As a rule, plastic materials are considered non-toxic, since they are assimilated by plants or animals. Risks may arise however, from the additives incorporated in plastics. Slow decomposition of some types of plastics (eg. polyesters, polyamides) in landfills can cause leaching of chemicals into the groundwater (these include heavy metal compounds and other substances whose nature is difficult to predict or which are proven to be harmful. Uncontrolled burning of MSW on dumpsites, as practised in developing countries, is ecologically unacceptable in view of the uncontrolled air pollution and emission of toxic fumes. Equally questionable are unhygienic forms of scavenging (among others, of metals and plastics) from landfills (U.N., 1992).

The NCAER carried out a survey during 1987 - 88 for the IPCL, and this survey has recorded and quantified the plastics wastes as available and recycled in major metropolitan towns and cities in India. According to this survey, the plastics reprocessing/recycling industry comprises over 2000 units (it is now estimated that there are more than 20 000 units in the country) with an output of 323 209 tonnes (now probably 10 times more). This represents 37.2% of total thermoplastics available in the country (domestic production and imports) at 3.5 lakh tonnes during 1987 - 88 period. It was expected to increase at the rate of 5% per year with availability of around 2.5 million tonnes of various plastic materials with plans for expansion and diversification of petrochemical industry by the close of this century. The management of plastic waste could be a major problem. Their collection, sorting and recycling and reuse judiciously for identified critical and noncritical applications with a view to recover the raw materials, are important issues that need to be regulated and coordinated. The binding properties of plastics waste which is not desirable for further recycling, hold out promise of use in association with fillers for processing into composite materials. The composites find useful applications like fence posts, park benches, pallets and road furniture as substitute to timber and concrete products. In India, not much attention has been paid in this direction, except one manufacturer (Ratra, 1992).

An important feature of plastics waste as discarded plastics articles is the delayed action in their disposal - unlike plastics discarded by consumers in advanced countries. In India also, packaging of goods has been carefully invaded by plastics - but the shopping bags or even milk pouches and the like do not get rejected in first use unless of course it is earlier made of poor quality recycled plastics waste (which will be reflected in its appearance and dirty colour). Their secondary use continues to flourish unless the bag/packaging becomes completely unserviceable. So is the case with partially broken plastic moulded consumer articles, like buckets, baskets, jerry cans and the like. Here again, the ingenuity of a few individuals has brought to the scene, the so-called "plastics - mechanics". These mechanics visit various residential localities on week days, and offer services to repair on the spot, broken plastic articles by the simple process of 'fusion'. So successful is the style of delayed disposal of 'plastic articles' that a plastic mechanic claims to earn Rs. 75 per day(ibid).

Another feature of plastics waste collection is through groups of kabadiwalas frequent localities, buy scrap plastics at varied rates (Rs.2 to Rs.10 per kg depending upon quality, grade and colours of plastic waste or even exchange the discarded plastic articles for consumer items like buckets, baskets and similar containers moulded earlier using recycled plastic with additional nominal cost. At first source collection levels, rates for plastic waste (depending upon its quality and colour) vary anything from Rs.2 to Rs. 20 per kg. Even the prices for recycled materials fluctuate more than the prices of raw materials, and this depends upon the quality of recycled material. However, depending upon the stage of recycling, the recycled material is priced at less cost as against the corresponding virgin material of the same type.

In Delhi - Jwalapuri is (was - after the major fire in 1995 which destroyed it, the traders have shifted to other places in Delhi) the nucleus market for plastics waste received not only from Punjab, U.P., Haryana, H.P., Jammu & Kashmir but from all parts of the country including southern and north-eastern states. Other important centres are Bombay, Calcutta and to a much lesser extent, Madras, Bangalore, Ahmedabad and Kanpur. PVC 'chappals' (sandals) account for the bulk of plastic waste recycled every day in Delhi. Plastic bags , discarded bottles and films follow. While almost 80% of PVC 'chappal' market depends on use of recycled plastics, over 50% of plastic bags (vegetable/fruit/grocery shops) today depend almost totally on recycled plastics because of price factor vis-a-vis virgin material. Part of recycled material finds its way to waste after four or more recycling cycles and after completing its useful life with the consumer. With increased consumption of plastic goods (at present it is 1.2kg/capita/day), the availability of increasing quantity of plastics waste would continue to find its way for recycling in the years to come (Ratra , 1992).

On November 15, 1994, when the Corbett National Park opened to the public for the winter season, visitors were asked to carry their own litter bags while entering the Park and bring back their litter and leave it at the gate of the National Park while going out. This was to ensure that the non-biodegradable items which cause harm to the ecosystem, are not scattered inside the Park. Items not allowed to be thrown inside the park included plastic bags, plastic bottles, tin cans, glass bottles and empty wafer packets. This precaution was taken to ensure that animals don't swallow non-biodegradable matter since it caused death in most of them (The Hindu, 1994).

Considering that 60 per cent of the world's inhabitants live less than 60 kms away from the sea, 80 per cent of all floating debris emanates from the land. The situation has worsened over the last 25 years with tyres, soft - drink cans, nylon fishing nets and plastic objects (they add upto 80% of the rubbish) littering beaches and befouling the sea. The U.S. National Academy of Sciences estimates that ships and fishing boats dump some 48 00 000 metal cans, 3 00 000 bottles and 1200 tonne fishing nets apart from more than a million tonne of assorted rubbish every year (Indian Express, 1994). Every year during summer and rainy season, one reads in newspapers about epidemics of malaria, cholera, typhoid, gastroenteritis, viral fevers and two years ago - pneumonic plague in many parts of the country. Most of these are due to water contamination from contaminated sources - landfills dumpsites or due to mixture of sewage and water supply because of low water pressure. Mosquito menace is due to overflowing drains and stagnant water in pot holes and terraces. Drains further get clogged by non-biodegradable matter which get into drains and clog the pipes thereby causing methane gas build up and bursting of the pipes as it happened in Delhi late last year. A substantial portion - nearly 50% of non-biodegradables is plastics (Krishna, 1994).

Recycling of packaging used for potentially hazardous products draws attention to the estimated 70 000 tonnes produced each year by this waste stream. While it is technically feasible to recycle it, a number of problems exist with collection, processing and finding markets. ... Of the materials collected, paint is the largest single category, typically 40 - 60% by weight, with oil accounting for

20% . The other materials collected include pesticides and batteries. Processing oil containers which are metal does not present much of a problem. These can be processed through a fragmentiser or shredder. The action of the latter tends to transfer the oil onto the dirt, which is removed. Most oil containers are now plastic, and studies by the Centre for Plastic Recycling Research in the US show that due to the nature of the contaminants, packaging for oil, paint and pesticides must be handled separately. A further problem is that some of the hazardous ingredient is likely to be absorbed into the material (Poll, 1995).

This can affect the physical properties of the recovered polymer possibly even restricting potential end uses. Markets which have been found include reuse as packaging for similar products. Oil containers containing 25% post consumer material are now produced in the UK. Trials are also underway to produce new paint containers from old. In Canada, trials have suggested that material from pesticide containers could be used to manufacture fence posts. Suggestions include that other forms of recovery such as incineration with energy recovery may currently be the best option (ibid).

Unfortunately, when recycling technologies regarding post-consumer waste is ridden with so many problems, public education programmes all over the world including developing countries are promoting the idea that recycling is a panacea for all environmental ills anywhere in the world. It is also extremely unfortunate that many developed countries are exporting their solid wastes, especially contaminated plastics and infectious hospital waste in the pretext of helping the poor in these countries who according to them are dependent on recyclable waste for their livelihood. Countries in South and South East Asia region are very vulnerable to this kind of propaganda, that the support of recycling industries in our countries would amount to helping the poor. Many countries in this region are in the throes of economic reform and rapid industrialisation and populist governments elected on the manifesto of providing employment would support such imports into our country even it means giving the go-bye to pollution control laws (SASEANEE - SWAST, 1994).

Trade between countries in any kind of toxic substances is now covered under the Basel Convention to which 65 countries including India are signatories. The signatories of Basel convention have banned trade in toxic substances especially export or import of waste for dumping. Toxic trade resulting from noxious waste exports has begun to be understood as an environmental crime, that is perpetuated, more often than not, by the stronger partner. This is happening even as 95 countries, including those in Africa and Central America, have banned the import of hazardous wastes in their territories, much of which comes from global giants like Australia, Canada, Germany, Japan, England and the US, in the guise of recycling. India too has been importing waste for recycling which it considers nonhazardous. Between 1993 to 1994, 114.4000 tonnes of copper, 365.6000 tonnes of paper and 7.8 million kgs of plastic from the US, and 7.4 million kg from Australia have been imported. This kind of import of wastes may not affect the upper level of middlemen and factory /unit owners in the chain of recycling but would definitely affect the ragpickers' livelihood and that of kabadiwalas and petty agents who all depend on the collection made by the ragpickers and sold to the agents (Chaturvedi, 1994). "Even countries such as Germany with the latest technology are not able to recycle all the plastic they use. It produces 4.15 lakh tonnes of plastic waste a year but can recycle only 1.65 lakh tonnes The rest is dumped in India and in other south east Asian countries. " (Malik, 1996). Jwalapuri in Delhi, before the fire on June 6, 1995, was also the dumping ground for large amounts of imported scrap from Saudi Arabia, Nepal, Germany, Singapore and the US. Recycled plastic has a shorter lifespan than the original and is therefore cheaper by at least 20%. It is not correct to claim that plastic products especially PET will not pollute because in a closed loop recycling with no new resource input as is being claimed to be done at Manali in Madras, "no waste out" as claimed is not possible. Each time plastic is reheated, its chemical structure changes and the quality degrades. "Instead of a pepsi bottle going to a dump in California, a few months later you have a piece of polyester going to a dump in India". (Warrior, 1994).

What is not being understood is how a technology which is considered to be hazardous in America can be justified in India on grounds of economics and human health. After all, if plastic recycling creates an insurmountable problem of solid wastes, releases toxic emissions harmful to human health in the US, how can it be not inflicting the same, or perhaps more destructive blow to the environment in India (Sharma, 1994)?

METHODOLOGY

A. Methods of collection of plastic waste, human involvement and health hazard :

i) By direct observation of collection by ragpickers, other waste retrievers like those with tricycles , those involved in house to house collection and on contract basis from colonies, campuses etc, domestic servants, corporation workers, other kind of urban poor - destitute women and children .

ii) Survey on collection by ragpickers, itinerant waste collectors, petty waste buyers, wholesale dealers and manufacturers, in Delhi and nearby places to study the collection system and value addition at each stage through sorting, picking ,screening, washing etc.

B. Methods adopted by plastic waste recycling industry to segregate the mixed plastic waste:

Direct observation of ragpickers on roadsides and pavements where they sort before selling, visit to market places and agents where mixed plastic waste is sorted before selling to wholesalers, interviews on quantity , quality and different kinds of plastic wastes.

C. Type of equipment and process adopted by plastic reprocessing industry:

i) Visit to plastic reprocessing units and classifying and enumerating them as material (homogeneous plastics recycling), mechanical (mixed plastics recycling), chemical or feedstock reprocessing.

ii) Direct observation and collection of technical information on all types of equipment used with special emphasis on what kind of waste is recycled using which type of equipment, what are the temperatures prevailing at different points in the total machinery, whether washing of waste done and how ; assessment of how efficient that would be as regards the particular type of plastic, its level of soiling or contamination; what types of safeguards for preventing heating beyond the required temperature, safeguards if any for fumes emitted during heating, melting etc. ; what measures of protecting the workers against dust from grinding or size reduction, from fumes emitted from reprocessing equipment, what measures to protect the environment from fire, dust or particulate pollution, gases and residues.

iii) A total of five plastics reprocessing units were chosen for air quality monitoring in the premises. Air quality parameters such as total suspended particulate matter, SO_2 , CO, NO_x, at the work-place were monitored. Temperature near the working zone and inside the extruders were also measured. In case of PVC processing units (both cable making), HCl, Vinyl chloride monomer, Pb, Cd were determined. In addition, in a PS processing unit, styrene was also attempted.

iv) Age and condition of equipment being used for reprocessing were noted.

D. Hygienic condition prevailing in the plastic reprocessing units:

i) Collection of data from as many such units regarding types of plastics reprocessed, their source, the state in which they are received - whether sorted according to types of wastes or product from which other material could be made or according to colour, pigment or dyes, whether any distinction between contaminated or clean waste, whether only films or consumer items recycled; any restriction or preferences and reasons for such restrictions.

ii) Formulation of regulations regarding plastic reprocessing in India for possible use by organisations like the Bureau of Indian Standards.

E. Survey of generation, reuse and disposal of plastic waste

Since most of the methods selected for the LCS (Life Cycle Study) were to be by direct observation and visual recording as described in the Methodology, except in case of experimentally measuring the indoor, workplace air pollutants inside plastic reprocessing units (which was carried out in five representative units in Delhi - National Capital Territory), a survey tour was undertaken in July - August 1995 to several places in northern India such as Pathankot, Jalandar, Bilaspur, Shimla, Chandigarh, Dehradun, Rishikesh, Haridwar, Meerut, Roorkee and Ghaziabad, Moradabad, Bareily, Lucknow besides Delhi to specifically study the plastic waste management problems and issues and to make direct observations on the collection, sorting, value addition if any, reprocessing, conversion to products and final disposal of plastic waste. The tour was for 20 days and in each city or town visited, one or two ragpickers and at least one kabadiwala (itinerant waste buyer), were identified and interviewed according to a short interview schedule prepared earlier (attached as Appendix 1 & 2). The interview schedules were for finding out the type of waste that the ragpicker or kabadiwala collected or bought, whether they picked up or bought plastic waste. What was their total earnings per day and whether they had associated health problems in this kind of waste related work?

In most places, visits were made to colonies, dumpsites, market places, busy locations like bus stops, railway stations, riverside (Ghats), hillsides and jhuggi jhompri (jj) clusters or slums to make direct observations regarding how ragpickers or others collect especially plastic waste and in relation to other kind of waste collected and sold to agents, sorted, cleaned and reprocessed/ transported and what prices do they fetch? Agents and kabadiwalas and roadside shops were visited, some prices of articles bought and sold, preferences, problems etc. were enquired and recorded. These interviews were by no means exhaustive or meant to establish any statistical relevance; the observations and interviews were exactly for the purpose as stated above - to make direct observation on the method of collection, sorting, cleaning, screening, processing if any and final disposal. In all steps the human involvement and health hazard were specifically recorded. Any kind of innovative approach, protective measure or gear or any special danger due to a particular kind of waste or situation were noted.

In Delhi - NCT, including Faridabad and Ghaziabad, plastic waste dealers, wholesalers and plastic reprocessing units were visited and specific detailed interviews regarding type, kind, quantity and quality of plastic waste got from ragpickers, kabadiwalas, contractors, householders, servants or got from outside were recorded (interview schedule in Appendix 2 & 3) ; buying price, selling price, sorting, cleaning operations, cleaning and processing were also noted and detailed charts to give the basic data on traders, units, economic and environmental data are given in the results. Location maps of traders, agents and plastic reprocessing units in Delhi - NCT has been prepared and is placed in the Appendix 6. The summaries of the data are given in the results. In addition, a study undertaken in the months October - November to look at some of the best practices regarding solid waste management in Bangalore and Madras (CEE, 1995, CEE and EXNORA, 1995) gave a very good insight into the way plastic waste is being collected, sorted, traded, washed/cleaned, processed and marketed in these two cities. Therefore the results of those two studies too regarding plastic waste recycling was collated in the present study to give a better view of the existing situation in India although the observations recorded here are with specific reference to Delhi and its environs.

For visiting the plastic reprocessing units in Delhi including Faridabad, Ballabgarh, Gaziabad, Gurgaon and NOIDA, a list of industrial areas in Delhi where small scale industries were located was obtained from from the Directorate of Small Scale Industries for the NCR of Delhi. Delhi has 28 declared industrial areas besides several villages and new resettlement colonies where small scale industries are present and are operating legally and illegally. Of the list of 30 localities or areas visited for this survey, most of them are notified industrial areas and others like Mangolpur Khurd, Phut kalan etc. where small scale plastic reprocessing units were identified and visited, the addresses were obtained from the All India Federation of Plastic Manufacturers situated in Delhi. In all these 30 localities, besides the Jhuggi Jhompri clusters for interviewing ragpickers and traders in various market places like Sadar Bazar, Nihal Vihar, Silampura, Jwalapuri etc., the randomness of sampling was maintained to the maximum extent possible although no particular system could be adopted since in many of the units, owners or responsible persons were not present or were unwilling to be interviewed.

Air quality monitoring was conducted in five units in Delhi, representative of PVC, HDPE, HM or carry bags, PS/HIPS for the parameters given in the methodology. In all units Total SPM was measured, in addition in PVC units respirable dust using fine filter paper, HCl, SO_2, NO_x, VCM (Vinyl chloride monomer), Lead, Cadmium were also sampled and analysed. In HDPE, PS/HIPS and HM units air samples for testing CO (Carbon monoxide) were trapped in bladders which were then tested in digital CO analyser in the lab. In PS/HIPS unit, air samples in DMA (Dimethyl Acetamide) were bubbled through bubblers in low volume air samplers attached to the HVS (High Volume Sampler) sampling for dust. The analysis of styrene sample was attempted by gas chromatography and the VCM sample was analysed in the laboratory by head space gas chromatography. Temperature in the workplace and outside as well as inside the extruder using digital thermometer was also recorded. Standard procedures were followed for our sampling and analysis. The analysis was mainly done at Shriram Institute laboratories. The results are given in the next chapter and the chromatograms are given in the Appendix 5.

RESULTS

The study, consisted mainly in observing and understanding the problems of plastic wastes in India and their management. Towards this end, the environmental conditions of plastic reprocessing units in Delhi's National Capital Territory (NCT) were investigated and air samples were taken within five of these units and subsequently analysed in the laboratory for presence or absence of general indoor air quality parameters and specific pollutants associated with plastics recycling industry.

The results and analysis of the responses of 18 ragpickers and 11 kabadiwalas who were interviewed during the study are given in Tables 1 and 2. Although, this is a very small sample, the significance was in getting their responses to the kind of queries being asked and also in observing and photographically recording some of their activities. A larger number of ragpickers and kabadiwalas were observed for their activity and the health impact of the kind of work they were doing either at or near the garbage bin or at the dumpsite was descriptively recorded which was made use of, while formulating the possible guidelines for the Bureau of Indian Standards regarding plastic waste recycling (proposed document attached in Appendix 4).

In Delhi, in addition to ragpickers, kabadis etc., contractors were also interviewed and organised door to door waste collection programmes such as carried out by the Cleaning Brigade etc. in Asiad village, inside Jawaharlal Nehru University etc. were observed. The results of these interviews are in the same table as those of ragpickers.

In the places mentioned above, officially designated dumpsites were visited and the fate of plastic waste thrown along with other municipal solid waste was observed and recorded. Also, housing colonies - mostly middle income and high income ones, institutions like schools, universities, campuses, shopping areas and complexes, railway stations, bus stands and in some cities congested markets and jhuggi jhompri clusters were visited and the condition and state of plastic waste was recorded. These observations were later collated with similar and other observations made in Bangalore and Madras, the two cities where surveys of best practices in solid waste management was carried out in the months of October - November 1995 on behalf of Centre for

Environment Education, Bangalore. The consolidated observations on the state of plastic waste in India, their contamination in first use, reuse, while collecting, their sorting, washing, reprocessing and the products made from them are summarised in Table 3.

As a result of these observations and recording, the life cycle of plastic waste as it moves from the consumer to the dustbin, or gets segregated and bought by the kabadiwala or as it is being organised these days in several cities, contractors take it away from homes for which they get paid, how the plastic waste really travels from ragpickers and contractors, through the hands of petty buyers, sorters, wholesalers finally to the reprocessors where after a final sorting and cleaning, is melted and reprocessed into granules or agglomerates, is an interesting as well as fascinating activity. This life cycle route has been represented diagrammatically in Fig 1.

From December 15, 1995 to March 31, 1996, a detailed survey was carried out in Delhi and surrounding areas, regarding waste collection points, petty buyers and traders dealing with buying and selling of plastic waste, sorting areas where huge quantities of plastic waste are sorted, dusted and removed of foreign material, the sorted waste is then put into gunny bags or HD/PP woven sacs and taken to Jwalapuri, Asia's biggest waste trading market (after the fire, people in Jwalapuri involved in waste business have shifted to different places and are now much more diffuse than what was earlier). About 300 plastic reprocessing units in 30 areas in Delhi, (a list of areas visited is given in List 1) were visited and surveyed according to an interview schedule earlier worked out on the basis of a shorter reconnaissance survey in December 1995. The interview schedule or the table of items to be recorded is attached as Appendix 3. Interview and not the questionnaire method was chosen as survey methodology because of paucity of time.

A summary of 45 units in 11 representative areas is given in Table 4. This table, besides giving basic data on the size and location of the unit along with their electrical capacity and number of workers, specifically deals with the type of plastic waste, quantity, quality, source, sorting and segregation, washing, type of equipment in each unit, the state and condition of the units, qualitative air and water quality, the condition of the employees, kind of additives and chemicals used during reprocessing, the temperature inside these units as well as inside extruders so that air quality inside these units can be said to have some relation with the heating of the thermoplastics and giving off of fumes. The survey was undertaken with the help of Shriram Institute for Industrial Research, Delhi.

A total of five units amongst those surveyed were chosen and specific indoor air quality parameters from these units were determined using standard ISI methods (procedures given in Appendix 5).

The results of these experiments are given in Table 5. Such sampling and analysis in more units is proposed to be undertaken in the coming months as well as a methodology to test the granules and products made in these units for the kind of quality and grade of plastic is being currently worked out for future work.

TABLE - 1

SURVEY OF RAGPICKERS IN VARIOUS CITIES AND TOWNS IN NORTHERN INDIA

DATE/PLACE	NO.AND LOCATION OF RAGPICKERS INTERVIEWED	TOTAL EARNINGS PER RAGPICKER PER DAY	RATE OF SELLING PLASTIC; OTHER ITEMS SOLD	HEALTH PROBLEMS
26 .7.'95, Delhi	two, at the roadside garbage bin	Rs.100	Rs. 1 to Rs.3/kg; other items like glass, metal, aluminium, paper	never went to doctor; no protection while picking from garbage
27.7.'95, Pathankot	two, garbage bin and dumpsite	Rs. 75 - Rs. 100	Rs.2/kg, glass, metal, rubber	not known; no protective gear or mask, clinical waste handled
29.7.'95, 30.7.'95, Jalandar	four, dumpsite , one at garbage bin	Rs. 75	Rs. 2/kg, paper, rags	get pricked by needles, unbroken syringes fetch a good amount; Don't know what is toxic
1.8.'95, Bilaspur	two, roadside	Rs.55	50ps to Rs.2/kg, glass, aluminium	"yes, but what to do?"
4.8.'95, Chandigarh	two, roadside near garbage bin	Rs. 100	Rs.3/kg; paper, metal, glass, aluminium	"yes, can't do anything"
8.8.'95, Delhi	eight, J.N.U. Campus Cleaning Brigade	Rs. 800 p.m.	Rs. 2 to Rs.3/kg, glass bottles, metal	are provided with gloves and uniform but complain of long hours of work; households do not segregate waste
9.8.'95, Ghaziabad	one, near dumper truck	Rs.75	Rs. 2 to Rs.3/kg, glass bottles, metal	not aware; collect all kinds of plastic - injection syringes, LD bottles from hospital fetch good price
9.8.'95, Moradabad	one, near dumper truck	Rs.55	Rs. 2 to Rs.3/kg, rags, aluminium	not aware; go to backyard of hospital to collect good stuff, rest burn
10.8.'95, Bareilly	two, one at garbage bin, one under a tree	Rs.50 to Rs.75	Rs.2 to Rs.3/kg, paper, iron articles	no hospital waste . collect only from bins and roadside
12.8.'95, Lucknow	one, at the roadside garbage bin	Rs.75	50ps. to Rs.3/kg, bottles, metal scrap, aluminium	has problems related to health

TABLE - 2

SURVEY OF 'KABADIWALAS' ITINERANT WASTE BUYERS AND TRADERS IN SOME CITIES IN NORTHERN INDIA

DATE & PLACE	NO. AND LOCATION OF 'KABADIS'/ PETTY BUYERS INTERVIEW -ED	TYPES OF PLASTICS SOLD OR BOUGHT	RATE OF BUYING PLASTICS FROM RAGPICKER, HOUSEHOLDERS, SHOPS, INSTITUTION, SCHOOLS , GODOWNS	RATE OF SELLING DIFFERENT PLASTIC MATERIAL AND TO WHOM	HEALTH AND OTHER PROBLEMS RELATED TO WASTE TRADE
26.7.'95, 23.2.'96, Delhi	seven; Welcome (Silampur), Alaknanda, Ring road	LDPE, PP, PP - PRINT, HM, HM - PRINT	Rs.6 to Rs.8/kg for clean HDPE, LDPE from households etc.; Rs.2 to Rs.3/kg for roadwaste; maximum for commercial, industrial waste Rs. 20 to Rs.22/kg for LDPE, HM from shops, godowns	To wholesale traders or directly to reprocessing units; LDPE at Rs.30 to 35/kg, PP at Rs. 27 to Rs.28/kg, HM at Rs. /kg, Roadwaste sold at Rs. 4 to Rs.5/kg with 'bapasi'	"Ragpickers are little thieves, they steal anything and sell it to us, people come to us asking about them"
277.'95, Pathankot	one; Highway	LD, HD, PP, HM, 'tripal' (tarpauline), not much road waste;	Rs. 15/kg for 'milk' and 'daru' LD; PP - a little less; roadwaste - Rs.1 toRs.3/kg	Wholesalers, reprocessing units in some other cities, agents; Rs. 22/kg for 'daru'	ver few ragpickers;
1.8.'95, Bilaspur	one; near bus stand	PP, LD, HD, PET, PVC sometimes and bottles	Rs.3/kg given to ragpickers for road waste; rest to kabadis and directly packaging or shop waste bought and cleaned - sorted. Rs. 10 to Rs15/kg for sorted and cleaned LDPE, otherwise deals with HDPE blow cantainers - Rs.10 to Rs.12 /kg for good quality blow containers including PVC water bottles;	Reprocessing units not there in Bilaspur, but in Chandigarh, Faridabad, Delhi . - several units; Road waste - Rs. 3 to Rs.4 /kg - minimum for any waste; HDPE blow type, containers washed, cleaned and sometimes sold to customers for reuse; Hard PVC water bottles - Rs.15/kg, others Rs.15 to Rs.20/kg	Health of ragpickers, sorters affected; several times they take advance etc. from petty buyers to attend to their medical problems - mostly eye irritation, wheezing, coughing and respiratory disorders;
3.8.'95, Chandigarh	one; near Chandigarh municipal corporation; some kabadis are found in Sector 25 where there are JJ (jhuggi jhompri clusters	Large containers, LDPE, PP etc. fetch maximum price /piece or kg; waste then sorted, cleaned and sold to reprocessing units; road waste not preferred, just to make up volume, many	HD, LD cut sheets fetch maximum price; also this kabadi prefers to buy woven sacs of PP, HDPE and some blow moulded articles like containers for which he pays Rs. 8 /kg if he has to get it cleaned, otherwise he pays Rs.10 to Rs.12 /kg if cleaned;	Sells cleaned, shredded, and colour sorted containers directly to reprocessing units; sometimes when waste not clean like as collected by ragpickers and hence called roadwaste, fetches very minimum/kg; on the other hand different sorted and good	most ragpickers and sorters have skin problems like itching, psoriasis etc.

DATE & PLACE	NO. AND LOCATION OF 'KABADIS'/ PETTY BUYERS INTERVIEW -ED	TYPES OF PLASTICS SOLD OR BOUGHT	RATE OF BUYING PLASTICS FROM RAGPICKER, HOUSEHOLDERS, SHOPS, INSTITUTION, SCHOOLS , GODOWNS	RATE OF SELLING DIFFERENT PLASTIC MATERIAL AND TO WHOM	HEALTH AND OTHER PROBLEMS RELATED TO WASTE TRADE
		buy road waste very cheaply at 50ps to Rs.1./kg;		quality waste fetches high prices;	
12.8.'95, Moradabad	one; close to the market place;buys, sells all sorts of plastics including road waste, industrial waste etc.	Buys waste from all sorts of places; mostly various kinds of thermoplastics incuding broken wires, cables, conduit pipes, black jerry cans,roadwaste	Prices range from Rs. 7 to Rs.8/kg for poor quality and broken items like broken HDPE containers etc., Rs.9,10 upto Rs.12/kg for wires and PVC pipes, Rs. 25/kg for unbroken containers and for cables with copper etc in it	Sells different materials to different people; mostly sends high quality HDPE,HM,PVC bottles to Delhi for reuse and reprocessing; removes copper, aluminium from cables,wires and sells to cable reprocessing units in Delhi Vishwasnagar at Rs.25 to 30/kg; sells batteries for reprocessing too;	Too much plastic around these days; earlier doing metal scrap business. now changed over from metal etc. to plastic but plastic is very cheap and too light. therefore have to collect alot, storage is a problem; besides cleaning etc. a nuisance
11.8.'95, Bareilly	one; 16 on the main road to Lucknow	HDPE, LDPE, PVC, Chappals	Rs. 10 to Rs.15/kg for good quality LDPE, HDPE; Hard PVC bought from houeholders, shops,offices, even hospitals; PVC chappals collected by ragpickers etc. bought for Rs.5 to Rs.8 per kg and PVC soles bought for Rs.2/kg	Sold to reprocessors in Delhi, Ghaziabad etc.; PVC chappals sold through agents in Jwalapuri, Trinagar etc. for exclusively making seconds chappals, sandals etc.; this kabadi collects old PVC chappals and sandals from Lucknow, Bareilly and other places up North like Haryana, U.P., H.P. Each state according to climatic conditions has varying quanitites of plasticisers, virgin material etc. prices also vary accordingly; for eg. discarded PVC chappals from H.P., J&K etc. fetch Rs.18 to Rs.20/kg due to	Plastic waste trading is a fluctuating market, a lot of variation in prices; also seasonal - from Holi to Diwali (March to October/November - good business. after that dull and market picks up only after winter.

DATE & PLACE	NO. AND LOCATION OF 'KABADIS'/ PETTY BUYERS INTERVIEW -ED	TYPES OF PLASTICS SOLD OR BOUGHT	RATE OF BUYING PLASTICS FROM RAGPICKER, HOUSEHOLDERS, SHOPS, INSTITUTION, SCHOOLS , GODOWNS	RATE OF SELLING DIFFERENT PLASTIC MATERIAL AND TO WHOM	HEALTH AND OTHER PROBLEMS RELATED TO WASTE TRADE
				good quality plasticisers and soft material	
12.8.'95, Lucknow	two; near walled city - bada imambara	kabadi bought from households, shops, offices, schools and hospitals; in addition about 50 ragpickers also sell their collected material to these agents who also buys from two or three 'pheriwalas' (itinerant waste buyers); good quality waste available only in shops, offices, factories; hospital waste - very good quality but ridden with problems; besides it is illegal; if somebody finds out - fine, imprisonment;	You need capital to buy waste and until resold, money locked up; household articles and broken plastic from homes, shops, offices and commercial establishments bought at Rs. 8 to Rs.15/kg; Hospital waste, 'daru', 'milk' and other oily cans which are good quality but requires washing etc. Rs.7 to Rs.10 or Rs.12 /kg; roadwaste and scraps of plastics, packagig etc.- Rs. 3 /kg ;	Finding the correct customer or reprocessor; waste sold at slightly higher prices, margin of profit - not much since money spent on sorting, cleaning, storing (sometimes have to hire a godown to keep the material); profit - hardly 5 - 10% after paying sorters, cleaners, purchase of detergents, water etc.; Normally 50ps to Rs1 spent on washing etc., good quality LDPE,HDPE etc. fetches maximum price - Rs.30/kg	Kabadi buying and selling is not a lucrative business: too much work and not even break even sometime; "gov't. should give tax incentive, insurance cover etc. By this way, it can ensure safety and assurance of poor people and help in saving the environment".

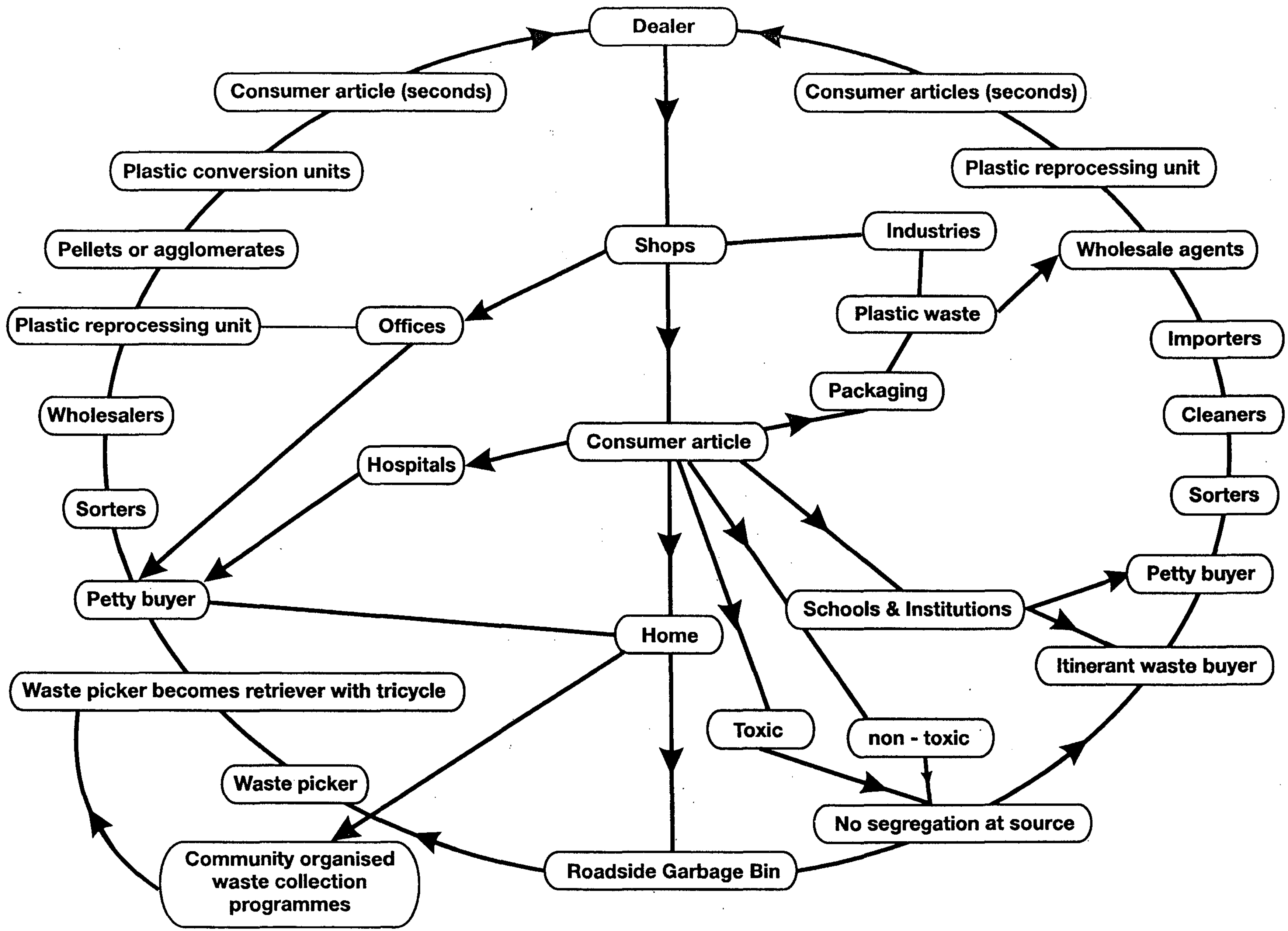
TABLE - 3

STATE OF PLASTIC WASTE IN INDIA - SOURCE, SEGREGATION, CONTAMINATION, PRODUCTS

Condition/parameter	Industrial	Agricultural, Commercial, Institutional, Hospital, Domestic	Road waste
Type of Plastics	Thermoplastics and thermosets; Thermoplastics incude films, blow and extrusion types, both also pre and post conversion wastes	Mostly thermoplastics - films, containers, moulded blow-moulded items and special application items such as medical, commercial etc.	Thermoplastics - blow moulded, other types of mouldings and application plastics;
Type of waste	Pre-consumer	Pre and post consumer	post-consumer
Reason for Generation	, Technology, Electrical fluctuations	Mostly packaging, disposable articles like food packaging, hospital and other clinical disposables, cartridges, also discarded due to loss of quality over a period of time, loss of colour, tainting etc.	discarded after one or several uses; consumer no longer wants it.
Available at	Source; eg. at manufacturing or conversion industry	With consumer - at source or with itinerant waste buyer - 'kabadiwala' who buys various grades, quality, polymer type and condition - broken, clean, with or without lid, cap at different rates	dustbins and dumpsites, gutters, sewers - in a totally discarded state; mostly in very poor condition and of degraded quality; rarely some items in good state - eg. one time use disposables like food packaging and mostly hospital and clinical discards;
Contamination	almost none, very minimal	Depends on what material packed; sometimes very little contamination, sometimes Equipment very highly conataminated like cleaning acids, solutions, motor, lube oils, paints, pesticides, batteries, photographic solutions etc.	Always contaminated - both by material packed in them such as food, beverages, clinical discards like syringes, catheters and canulas, single use cartridges of toner etc. and material used in contact with body fluuids, blood and human and animal excreta;
Quality as technical grade	Ranging from Excellent, good, fairly good	Categories include Good, fairly good, medium, poor, v.poor	medium, poor, v.poor, highly contaminated, shoud not be recycled;
Sorting and Segregation	Very little required; colour, grade etc.	Polymer type, colour, grade, blow and extrusion typeand ; contaminated not segregated;	Road waste sorted according to colour and state of cleanliness not according to contamination; several times recycled sorted

Condition/parameter	Industrial	Agricultural, Commercial, Institutional, Hospital, Domestic	Road waste
Washing and cleaning	Possible; very often not neceesary except when taken out of manufacturing unit for reprocessing elsewhere or if stored within the manufacturing unit in an improper way;	Possible , is being done, mostly soap, water, soda etc. used but some plastics cannot be cleaned because toxic principles like pesticides and components of paints enter the plastics ; also spores and viruses in clinical discards and other infected material may remain even after soap water washing;	At present not cleaned; sometimes if condition of plastic good - cleaned with soap water; thin films like carry bags etc. **never** washed; HDPE, PS cups etc. shredded and washed; fused packaging and metalised packaging washed with **acids ;** disposable food packaging and clinical discards slightly washed; PVC never washed;
Reprocessing	Primary reprocessing ie. quality similar to virgin material; 5 to 10% processed along with virgin material - grade not affected if no contamination; thermosets - possible only at molecular level;	Secondary reprocessing; quality, grade of plastic lower than virgin quality; post-consumer plastic undergoes photodegradation, degradation due to U.V. rays and contamination;	At present undergoes secondary reprocessing; consumer articles of cheap quality being made from even contaminated and/or infected plastics ; sometimes reprocessed articles reprocessed again several times;
Size & scale of Reprocessing unit and equipment	Large or Medium, also small scale sometimes; medium and large scale - equipment sophisticated, micro-processor controlled, clean and with temperature control, hardly any degradation;	Mostly small or tiny scale; old or run down equipment; even new equipment has no temperature control or microprocessor - totally manual or semi-mechanised; locally manufactured, cheap but functional;	Always small and tiny only; extremely run down machinery with no temperature control, no gas traps; even insulation is poor and plastic often chars; pollution is high;
Chemicals and additives	Not added; reprocessed as such except what normally added for virgin;	Waxes, oils, stabilisers, plasticisers and colours; sometimes flame retardants etc.	No chemicals except excess of fillers and sometimes secondary plasticisers; poor quality and highly toxic colours added;
Products	Same as virgin polymers ;	Seconds grade household and other consumer articles including carry bags, chappals etc. of slightly inferior variety and grade - cheaper;	Mostly slightly dull coloured carry bags, black jerry cans, jars for storing and transporting water, invert sugar syrup, ghee and oils, overhead tanks and many others;

FIGURE 1
LIFE CYCLE ROUTE OF PLASTIC WASTE IN INDIA



LIST 1

List of industrial Areas and other localities in Delhi NCR where plastic reprocessing units present

1. Badli
2. Ballabgarh
3. Bindapur
4. Budh Vihar
5. Bulanshaher Industrial Area
6. Faridabad
7. Ghaziabad
8. Geeta colony
9. Gokulpuri
10. Gurgaon
11. Jahangirpuri
12. Kamaruddin Nagar
13. Kirti Nagar
14. Mangolpuri Industrial Area
15. Mangolpur Khurd
16. Maujpur
17. Mundea
18. Nangloi Joct
19. Nangloi Sayed
20. Naraina
21. Noida
22. Okhla phase I
23. Okhla phase II
24. Peeragarhi
25. Puth Kalan
26. Ranholla
27. Sultanpur Majra
28. Tri Nagar
29. Vishwas Nagar
30. Wazirpur Industrial Area

TABLE - 4
SURVEY OF PLASTIC REPROCESSING UNITS IN DELHI - SUMMARY OF STATUS, 1996

Location & no. of units	Type of unit	Type of waste	Avg.qty of waste	Source	Scale & Avg. elec connection	Products	Unit dimension	Equipments	Sorting/ cleaning, drying	Hazards	Hygienic condition of unit	Employee condition	Air quality	Water quality
Trinagar,8	Pellets; one agglomerate	LD, HD, PP, PVC, HM	125 kg to 1000 kg	Post-con, comm., Indus, road waste	Micro, 12-15 HP	Granules, agglomerates	Small, medium	Grinder, Mixer, Extruder, Cutter, Hydro	Manual sort, dust removal, non-plastics, soap & water &sun dry	unsafe storage of waste, wiring unprotected, additive, colours toxic	Congested, small, all sorts of waste, no ventilation, not enough light	mostly look o.k, some have dust allergy, cough, wheezing, eye irritation	Dusty, Fumes, smell, in agglomerate unit strong smell of benzene, other PAH	Muddy, with soap and detergents water may contain infections, toxic chemicals etc.
Wazirpur, 6	all pellet making	PVC, HD, LD, PP coplymer, HIPS, EPS, Foot wear sole, carrybag	500kgs to 2000kgs	Post-con, road waste, Industrial	Micro (5 - 10 employees), 15 - 35 HP	Granules, Household products, Shoe soles, TV cabinets	small, medium, large	grinder, mixer, Extruder, cutter, moulds	Manual sort, PVC, Road waste, no washing, HIPS, LD, HD wash with soda, detergents, grease removed	Dense dust from PVC units - carbon black, toxic colours, wiring unprotected, no temp. control, PVC plasticisers and chlorine destroys Ozone layer	poor ventilation, congested, dingy, medium ones o.k.	poor, run down, Respiratory, eye irritation, some skin irritation	dusty with fumes, smell of CPW etc.	full of mud, soap; PVC units may have other chemicals too like lead , pthalates from plasticisers, toxic colour HD wash will have grease colour

Legend

Unit Dimension			Scale of unit		
v. small	=	< 60 sq. ft.	micro	=	5 to 10 employees
small	=	60 to 100 sq. ft.	mini	=	10 to 20 employees
medium	=	100 to 200 sq. ft.	medium	=	> 20 employees
large	=	> 200 sq. ft.			

Source of waster : postcon. = postconsumer; indus. = industrial; comm. = commercial;

Location & no. of units	Type of unit	Type of waste	Avg.qty of waste	Source	Scale & Avg. elec connection	Products	Unit dimension	Equipments	Sorting/ cleaning, drying	Hazards	Hygienic condition of unit	Employee condition	Air quality	Water quality
Naraina, 6	Cabinet telephones,PVC foot wear, granules for foot wear, Granules for TV & tape deck	HIPS, PS, PVC seconds granules, PVC used foot wear	500 kgs to 5000 kgs	Mostly post con and industrial	2 units - mini (employees - 10 - 20), four units micro (employees - 5 - 10) 23HP	telephones,TV cabinets, fresh footwear, seconds footwear, tape deck cabinets, granules	small, medium	grinder, mixer, extruder, cutter, moulds, hydro, finishing machines	Manual sort, PVC footwear not washed, HIPS, PS if industrial not washed	HIPS scrap inflammable, toxic fumes when burnt, wiring unprotected, colours - toxic, PVC additives have heavy metals, pthalates	Medium - o.k., small - congested, poor ventilation, some medium also poor	Seem o.k., better than Wazirpur, some have skin allergies and eye irritation	Dusty, smell of PVC, waxes, HCl, pthalates Pb, Cd, can be in the air causing allergies etc.	full of mud and soap if used for washing, otherwise cooling water may have lead due PVC plasticisers, HIPS units , water contaminated with colours
Mangolpur khurd, 6	Some pelletising, others conversion units	HD extrusion, blow waste; HIPS cups, cassette covers	800 kgs to 2500kgs	Postcon. Industrial, Commercial, imported	Micro, all units employees 5 to 10, 27HP	carrybags, granules for carrybags, cabinets, toys, lumps	small	grinder, mixer, extruder, cutter; carrybag mouldin showscarry bags,	manual sort, HIPS, HD, colour sorted, shredded and washed and sundried	Toxic chemicals such as colours, plasticisers having heavy metals, pthalates inferior or degraded polystyrene heated to high temperat	In HD, HM units, if ventilation poor, indoor air pollutants like So , NOx, CO SPM increases besides higher temperatures inside the unit; nature of waste - if mostly road waste - condition of	Better than wazirpur, still workers' condition extremely run down and many with skin allergies and eye irritation	were taken and analysed in the laboratory, presence of styrene was to be determined by gas chromatographic techniques by	Water from washings - extremely muddy, full of soap too; cooling water in cutter for cooling the extruded strands before being cut into pellets, may contain toxic colours, additives, plasticisers, heavy metals from colours, additives etc.;

Location & no. of units	Type of unit	Type of waste	Avg.qty of waste	Source	Scale & Avg. elec connection	Products	Unit dimension	Equipments	Sorting/ cleaning, drying	Hazards	Hygienic condition of unit	Employee condition	Air quality	Water quality
										ures to form agglomerates gives off styrene; electrical insulation poor - fire hazard, also storage of a lot of polymer waste wazzu within premises	unit deteriorates		trapping in Di-methyl Acetamide (DMA) could not be done due to non-availability of standard monomers of AR grade.	in addition, if plastic contaminated with pesticides, paints, cleaners, leachates in washes, water in cooling baths.
Phutkalan, 8	Mostly pelletising, some pelletising and moulding	PP film, HD,LD, blow , HD,LD mixed road waste, used woven sacs	500kgs to 3000kgs average 600kgs	Post con, industrial, clinical	all micro, 5 to 10 employees 38HP	Granules - totally transparent or grey merely by taking waste plastic of one colour or quality; other crystal like granules, brilliant colours, agglomerates for jerrycans - poor quality, smells	Small, some slightly bigger, medium size physically , low ceiling, wall height especially where carrybags melted and women sorters also inside dingy units to strip the roadwaste	Grinder, blender/mixer, extruder, cutter, extrusion tube fitted with several heating elements , no guard or protection against fumes, CO	manual sorting, also by using various chemcals to separate due to excess quantity; washing only of HIPS, PS, LD, HD (good quality; films	Automobile battery - PP copolymers, washing of battery waste container, to remove lead etc. is done with acid, which is let into	Mostly poor, ventilation inadequate, lighting poor, congested work space in some units, workers not given any protection by the units, sometimes they cover their faces with cloth, saree etc.	Poor, rundown, many, especially women are nutritionally deficient, so easily succumb to infections respiratory condition etc. Dust, very high; in	Dust - ver high; in addition battery reprocessing goes on, lead from batteries recovered , lead in residual plastic and indoor air -	Water muddy with detergents; Also acidic if acid used to wash PP; leachates from colour, heavy metal , PAH and other contaminants from material from earlier packaging; besides plastic in jerry can degraded since road waste charred ;

Location & no. of units	Type of unit	Type of waste	Avg.qty of waste	Source	Scale & Avg. elec connec-tion	Products	Unit dimension	Equipments	Sorting/ cleaning, drying	Hazards	Hygienic condition of unit	Employee condition	Air quality	Water quality
						because of excess charring - tainting of foodstuff, water, contaminated because made from road waste	and dust		only dusting and made into strips;	gutters - Phut-kalan is also residen-tial, and children play in the streets near gutter;			quality needs to be studied	tainting of substances stored in such jerry cans and jars
Sultanpur majra, 3	Pellets and carry-bags	HD, HM bottles, woven sacs, carry bags; PP waste	1000kgs	, post-consumer, 'bread' PP	Micro ; employees 5 to 10 28HP	jerry cans (black and blue, coloured recycled carrybags, shoe heels;	small and v.small	Grinder, blender/mixer, extruder, cutter, 'hydro' for draining water from washed HD shreds, innovative equiment for cutting thin PP or other film waste into strips and simultaneously remove dust	Manual sorting, sometimes some items alone sorted mechanically;	Use of acids, burning etc. - hazardous, wiring unprotected; stored thin film plastic - fire hazard; sorting road waste from garbage - highly infectious and toxic	very poor, congested, small, with low ceiling; units making jerry cans, in very dark, dingy, sheds;	At present, seem o.k., most of them are new and women are daily wage workers	Injerry can processing units where carry bags etc. being melted in extru-ders at very according high temperatures, strong smell of Benzene, PAH in addition CO formation cannot be ruled out	not significant since HM, PP waste not washed before reprocessing; however acids etc. used for sorting or cleaning, then effluent will be acidic

Location & no. of units	Type of unit	Type of waste	Avg.qty of waste	Source	Scale & Avg. elec connec-tion	Products	Unit dimension	Equipments	Sorting/ cleaning, drying	Hazards	Hyglenic condition of unit	Employee condition	Air quality	Water quality
Peeragarhi, 1	Pellets and House hold items	LD, HD mixed waste	2000 kgs	post consu-mer	Micro 5 to 10 emplo-yees 25HP	Seconds HD dustbins and buckets	Small	grinder, mixer/blender, extruder, cutter, 'Hydro' for washing and draining water, etc.	HD, House hold waste colour sorted manually only accord-ing to polymer type, colour, quality, not to contamin anants;	colour added to reproces sed HD - hardly uses master batches, mostly, powder colours contain-ing heavy metals etc.5	unit looks generally o.k., no obnoxious smell but because of heating plastic, typical odour, floor wet due to washing; ventilation etc. satisfactory, light adequate;	No protection for workers; nutrition-ally deficient, immunoc ompromis ed men, women and children sort, clean, wash reprocess HD wasteetc. which may be contamina ted since greater than 60% of all corrosive fluids, detergents acids, motor oils, paints, pestides packaged these days in light or white	Not very dusty, but neverthe less, dust due to grinding, dusting, washing-leads to suspend-ed particula tes in the air; besides powder colour - with substan-tial amount of heavy metals also may give rise to dust and air pollution	Full of dust, soap and colour

Location & no. of units	Type of unit	Type of waste	Avg.qty of waste	Source	Scale & Avg. elec connec-tion	Products	Unit dimension	Equipments	Sorting/ cleaning, drying	Hazards	Hygienic condition of unit	Employee condition	Air quality	Water quality
												coloured HDPE bottles etc. Toxic priciples enter the plastics and render them toxic;		
Badali, 1	Seconds PVC pelletisa tion and conver-sion	Used first grade PVC pipes	1000 kgs	post con-sumer, agricult-ural;	Micro, 5 to 10 emplo-yees 55HP	Two mm thick to Four mm thick irrigation pipes;	Small	Grinder, mixer/ blender, extruder, cutter etc.	Hardly any sorting required or done since waste used is of one quality and type;	PVC fire resistant but when burns, acidic and toxic fumes like HCl, dioxins and furans, Vinyl chloride mono-mer, SO NOx Carbon mon-oxide etc. emerge; when PVC cut or ground fine dust	Full of dust but condition of equipment good; temperature control etc. present Separate godown for storage of products	Empl-oyees condition o.k. but due to dust may be having respirator y eye disorders;	Suspend ed particula tes, respirabl e dust,	Water in the cooling zone or washing may get polluted due to plasticisers, fillers, colours;

Location & no. of units	Type of unit	Type of waste	Avg.qty of waste	Source	Scale & Avg. elec connection	Products	Unit dimension	Equipments	Sorting/ cleaning, drying	Hazards	Hygienic condition of unit	Employee condition	Air quality	Water quality
										particles fill the air causing dust allergies, asthma and other respiratory disorders besides, heavy metals in plasticisers, colours etc. make PVC hazardous;				
Vishwasnagar, 2	Seconds cables pellets and conversion	Used ISI grade cables	800 to 1500 kgs Average 1000kgs	Post consumer and Institutional	Mini 10 to 20 employees 37HP	Seconds cables; call themselves ISI grade but no checking, self testing and advertising;	Small, large	Pelletisation equipment - grinder, mixer, extruder, cutter etc.; for cable making, slightly different equipment for separating the copper atrands and	Sorting according to type, colour but in the case of cables made only from	PVC is fire resistant but when burnt, toxic fumes cover the place; Cables which are marked ISI but made	mostly o.k.; sometimes very dusty and dirty;wall , height low, increasing danger to unit and others;	employees condition o.k.,sometimes because of dust produced by grinding, pelletisation etc. respiratory disorders created;	Air quality to be determined since PVC gives off so many fumes when heated above 200 C	Not expected to be contaminated but cooling water will have leachates of plasticisers, lead, Cadmium etc.

Location & no. of units	Type of unit	Type of waste	Avg.qty of waste	Source	Scale & Avg. elec connec-tion	Products	Unit dimension	Equipments	Sorting/ cleaning, drying	Hazards	Hygienic condition of unit	Employee condition	Air quality	Water quality
								covering with cable emerging from seconds granules;		with seconds granules made secon-dary plastiser tend to lose their plasticis ers and cables become brittle and crack and cause fire hazards;				
Kirtinagar, 1	Pelletisa tion and conver sion	PVC ring pipes and toys	2000 kgs	Post consum er, Agri-cultural and Water depart-ment	Mini 10 to 20 emplo-yees 55HP	Inner core and tape of armoured cables	large	Pelleti-sation equipment of the same type - grinder, mixer/blen der, extruder, cutter etc.; in addition there are rotary blades to cut the ring pipes and slice them for	Sorting manual, no washing, only dusting or through blower	All PVC units have similar hazards of toxic fumes in case of fire; Also cables made from seconds PVC granules is not totally	Unit looks dirty and dusty because no proper maintenance and house keeping ; Inner chamber where tapes, and core being moulded, chamber with low walls and dark and	Employ-ees condition o.k. but comp-laints of headache, bodyache, eye irritation and dust allergies quite common	Air - full of dust , suspend-ed particu-lates, respir-able particula tes high, CO, SO NOx; Lead and Cad-mium in air not detected	Water polluted only because at the cooling zone, water contaminated with Lead and Cadmium from plasticisers and other heavy metals from colours but in this unit only carbon black used.

Location & no. of units	Type of unit	Type of waste	Avg.qty of waste	Source	Scale & Avg. elec connec-tion	Products	Unit dimension	Equipments	Sorting/ cleaning, drying	Hazards	Hygienic condition of unit	Employee condition	Air quality	Water quality
								facilitating grinding; conversion equipment for making tape, core different;		without hazards although the inner core and binding tapes are only physical elements in the armour-ed cables ; Equipment looks very old; poor house-keeping, so the entire unit looks rundown and dirty; storage of scrap within unit is a fire hazard;	dingy;		and no HCl or Vinyl chloride mono-mer detected;	

Table 5

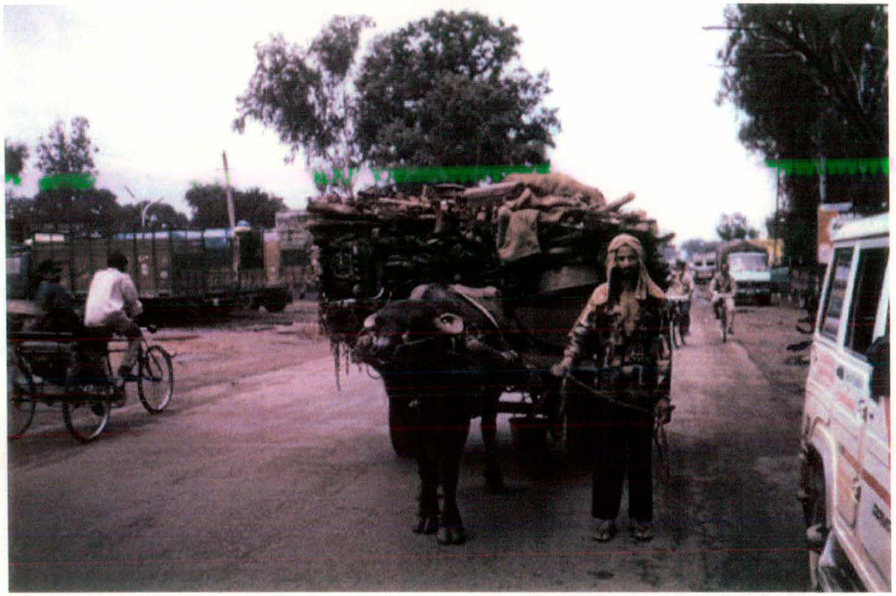
Air Quality Monitoring Data

Date of Sampling	Type of unit	Air quality parameters	Equipment	Method	Results	Remarks
21.3.'96	HD granules	Total suspended particulates	High Vol. Sampler *APM 415*	IS 5182	1094.04 μg/m³	Unit worked only for one due to repairs
		CO	*CO 11M* Analyseur		CO Undetected	
		SO_2 NOx	Low vol. sampler	IS 5182,II	undetected	
21.3.'96	HM Carry Bags	Total Suspended Particulates	High Vol. Sampler	IS 5182	699.6 μg/m³	No granule making *Low temp.*
		CO	*CO 11M* Analyseur		*CO* Undetected	
		SO_2 NOx	Low vol. sampler	IS 5182,II IS 5182,VI	undetected undetected	
21.3.'96	HIPS Granules	Total suspended Particulates	High Vol. Sampler	IS 5182	3517 μg/m³	Waste ground made into lumps & granules; strong smell of Styrene inside the unit.
		CO	*CO 11M* Analyseur		*CO* Undetected	
		SO_2 NOx	Low vol. sampler	IS 5182,II IS 5182,VI	undetected undetected	
		Styrene	GC(FID)		Qualitative Detection attempted	
9.4.'96	PVC Granules Tapes & Cores	Resp. & Total sus. Particulates	Respirable Dust Sampler *APM 451*	IS 5182	306 μg/m³ 2706 μg/m³	Waste ground made into granules; PVC granules for Tapes for armoured Cables & dummy cores. unit dim. well ventilated water sample taken at coolin trough after extruder Pb presence due to cols. & Plasticisers
		CO	*CO 11M* Analyseur		*CO* Undetected	
		SO_2 NOx	Low vol. sampler	IS 5182,II IS 5182,VI	undetected undetected	
		VCM	GC(FID) Head space		undetected	
		HCl, Chlorides		IS 10496	undetected	
		Cd in air & water	Spectra A	Flame	undetected	
		Pb in air & water	Atomic absorp. Spectrometer		Pb. in air is 0.03 ppm in water is 0.08ppm	

Continued on next page

24.6.'96	PVC Granules (Cables)	Total sus. particulates	High Vol. Sampler	IS 5182	473 $\mu g/m^3$	Medium size unit, usually uses fresh granules for making cables occasionally uses seconds granules; unit dim. large well ventilated.
		CO	CO 11M Analyseur		0.5 ppm	
		SO_2,	Low Vol.	IS 5182,II	18 $\mu g/m^3$	
		NOx	Sampler	IS 5182,VI	24 $\mu g/m^3$	
		VCM	GC(Headspace)		undetected	
		HCl		IS10496	undetected	
		Pb, Cd, in air	Spectra A Atomic absorp. Spectrometer		undetected	

TYPES OF RECYCLABLES COLLECTED BY KABADIWALAS AND PETTY TRADERS



TYPES OF PLASTIC WASTE

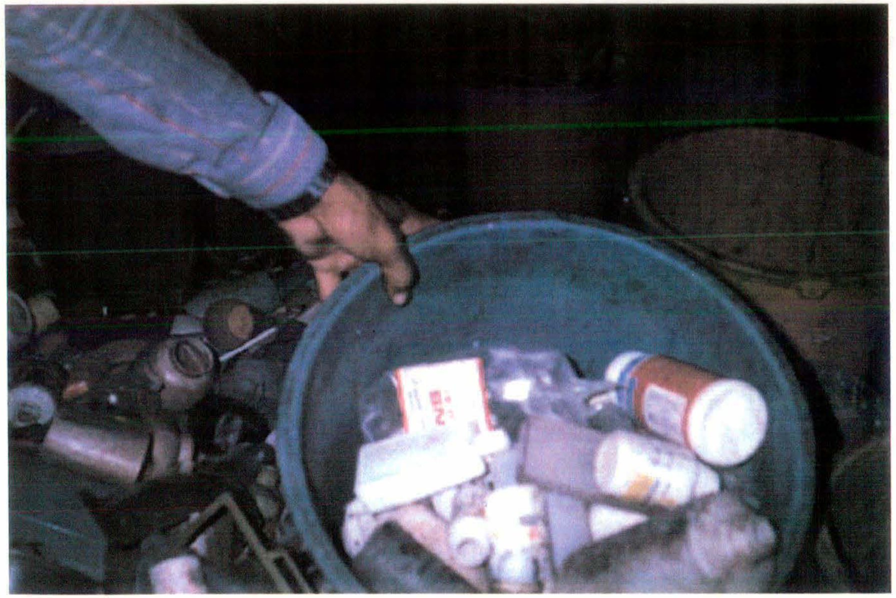
FILM WASTE OR ROAD WASTE

SINGLE COLOURED SACHETS

PLASTIC CONTAINERS

SORTING OF PLASTIC WASTE

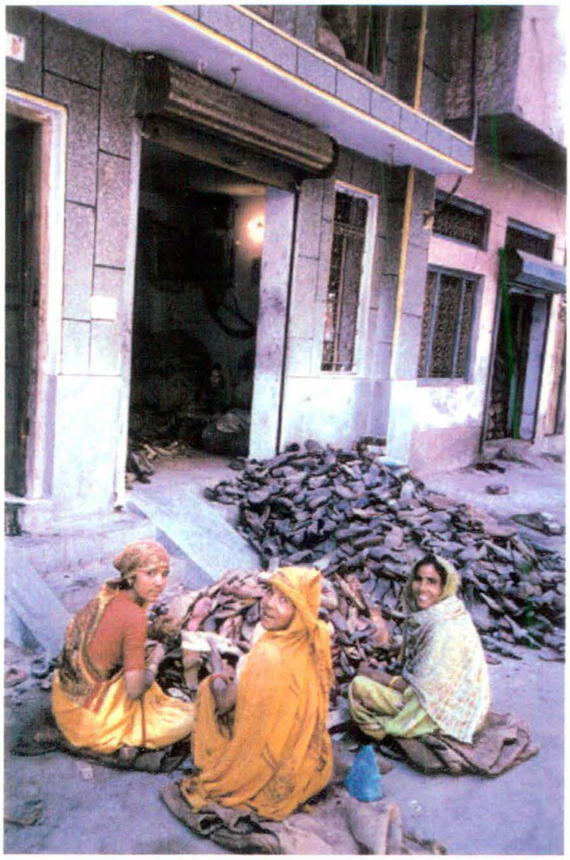
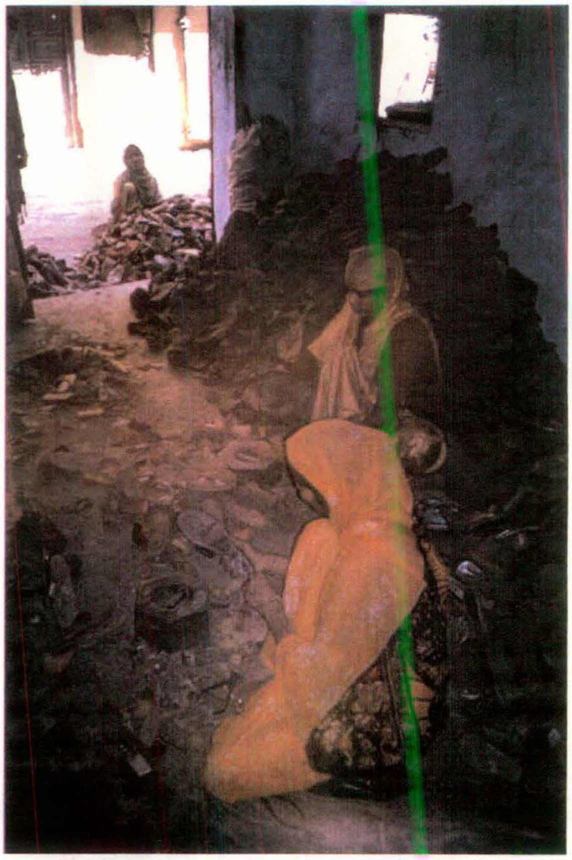
SORTING PLASTIC FILMS FROM PAPER



SORTING BLOW QUALITY SINGLE COLOUR (TOXIC, CONTAMINATED NOT SEGREGATED)

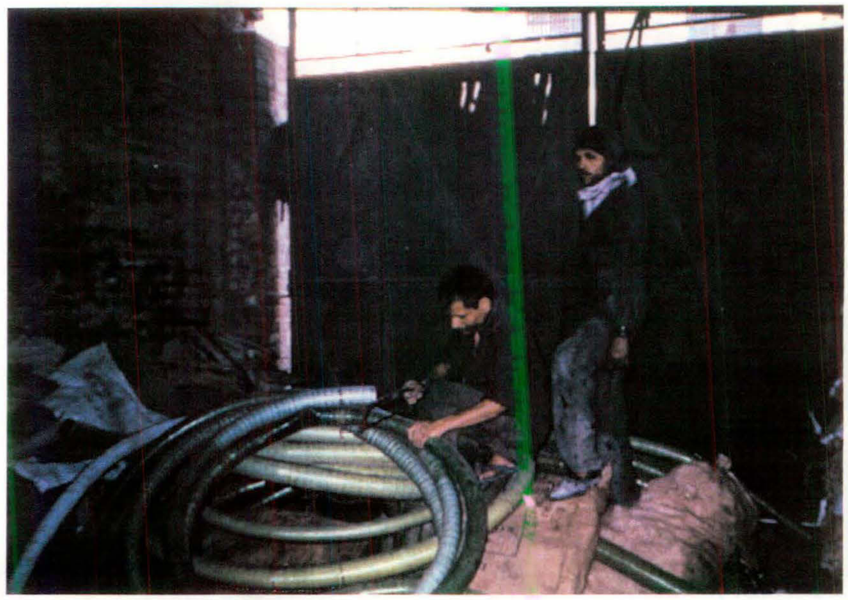
SORTED AND PACKED, READY FOR THE TRADERS

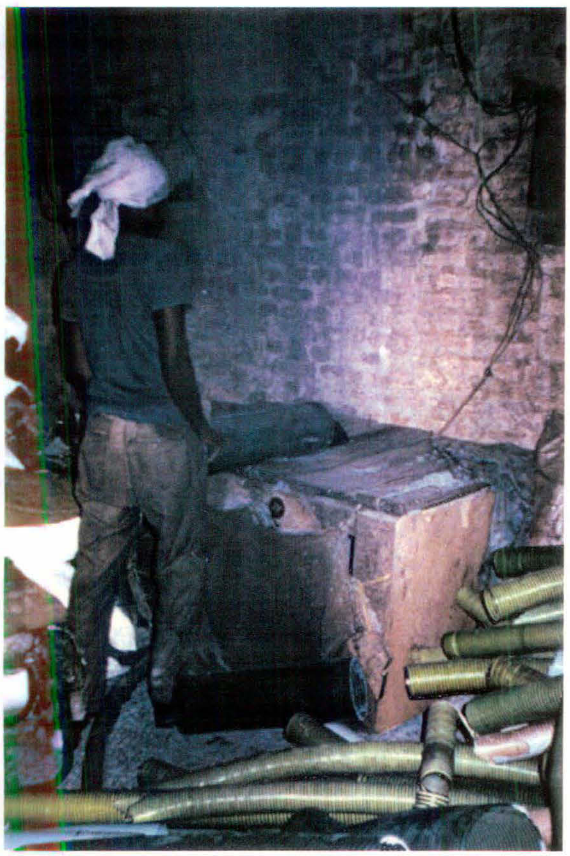
PVC FOOTWEAR RECYCLING

DISCARDED **PVC** CHAPPALS AND SANDALS BEING SORTED AND CLEANED

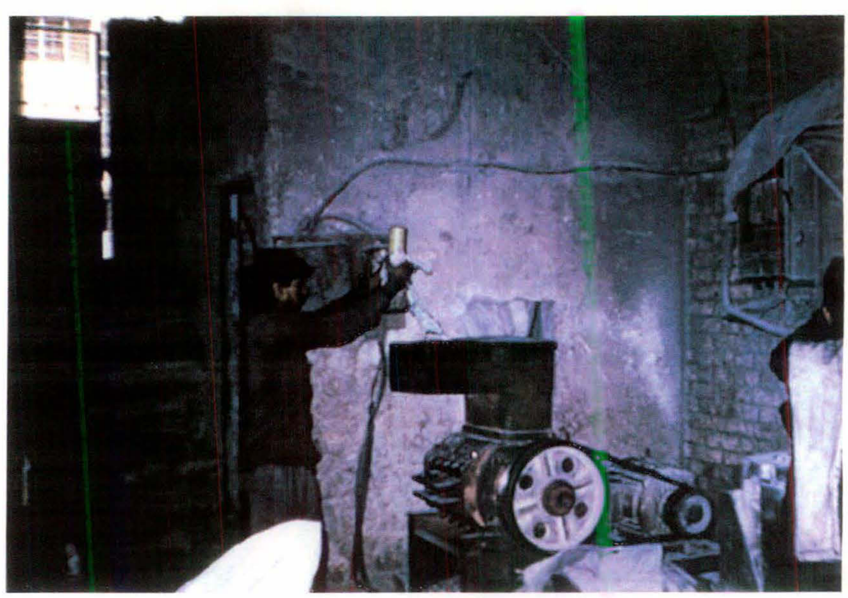
SORTED FOOTWEAR BEING GROUND FOR REPROCESSING AND CONVERSION TO SECONDS FOOTWEAR



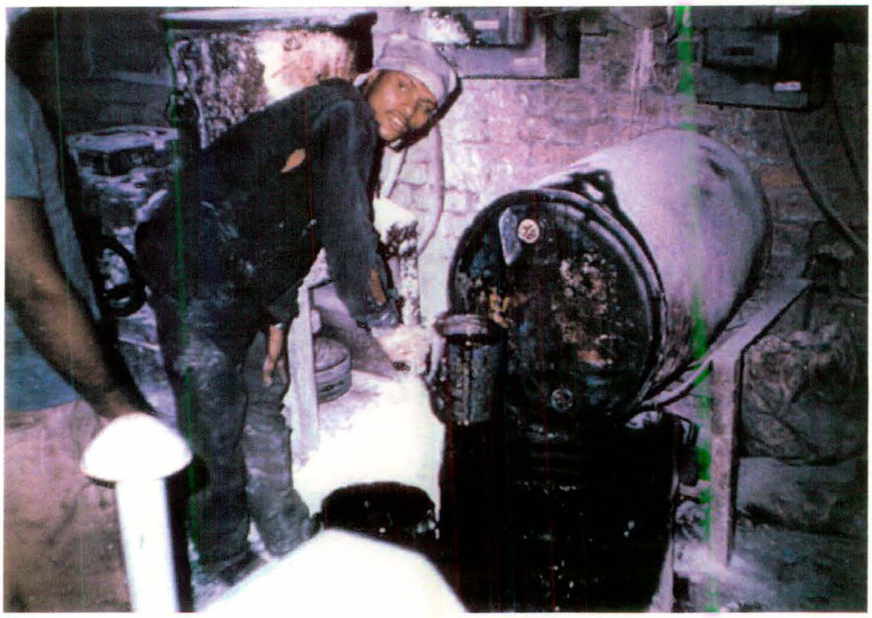


PVC

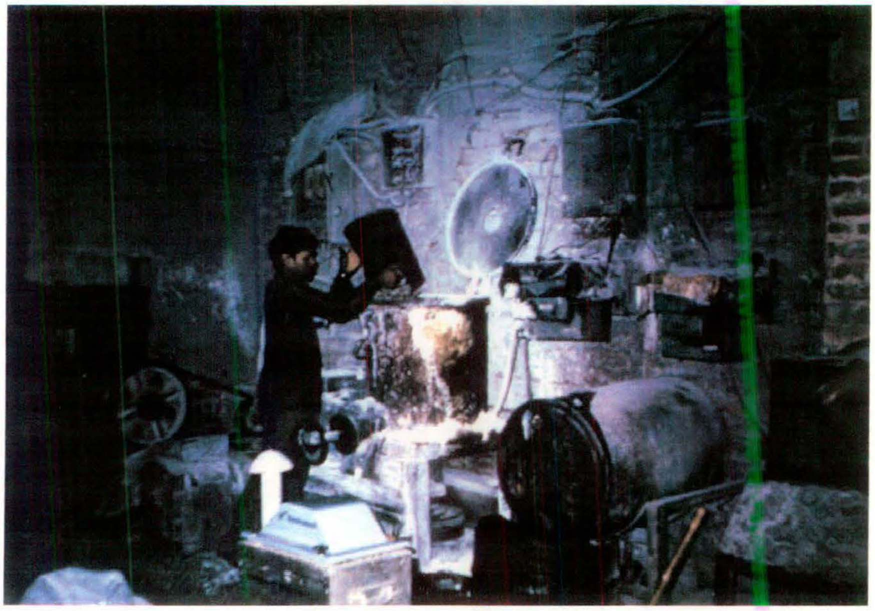
RINGED IRRRIGATION PIPES BEING CUT AND GROUND FOR REPROCESSING AND CONVERSION TO TAPES AND DUMMY CORES FOR PVC ARMOURED CABLES



BLENDING AND SOFTENING

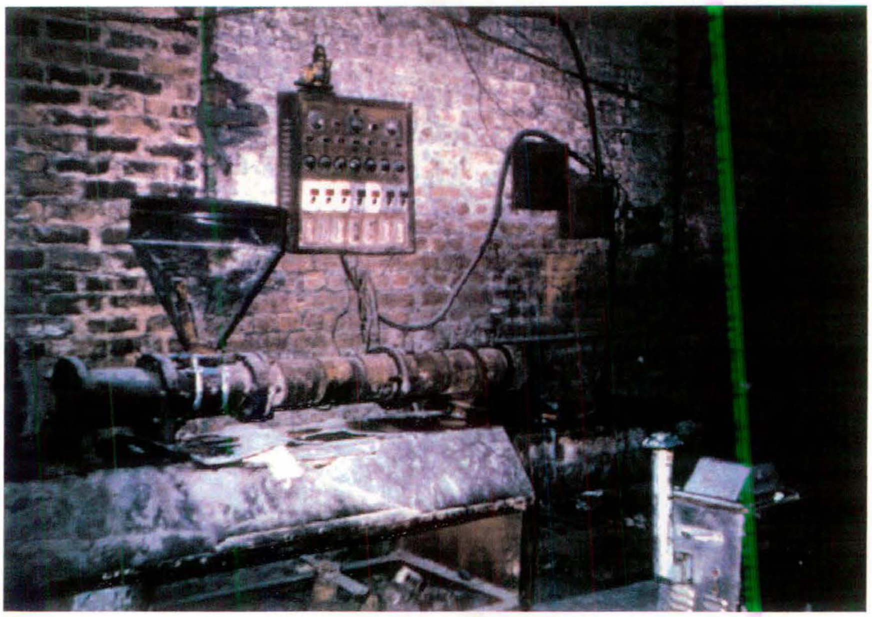


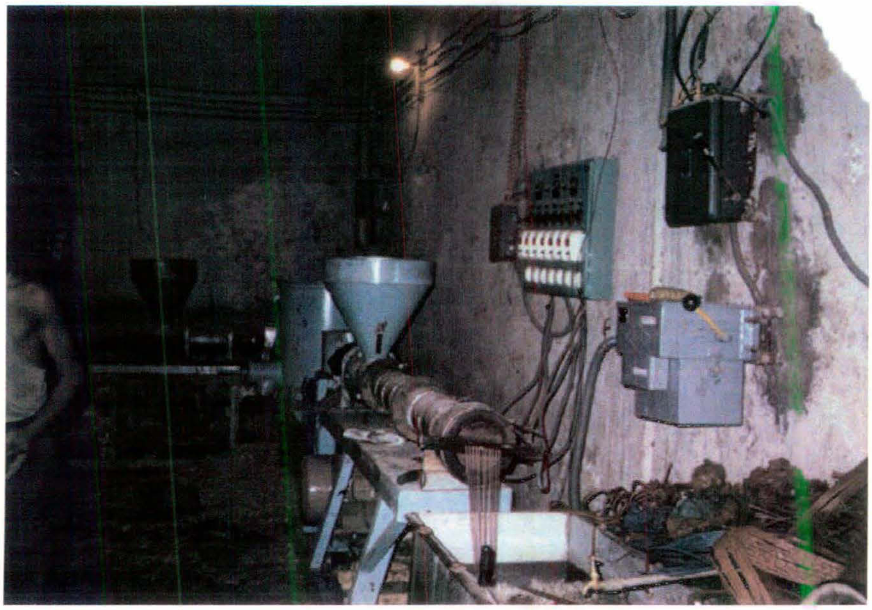
CHLORINATED PARAFFIN WAX (SECONDARY PLASTICISER) IN PVC REPROCESSING UNIT



WAX, COLOUR ETC. ADDED INTO A MIXER/BLENDER DURING REPROCESSING OF PVC

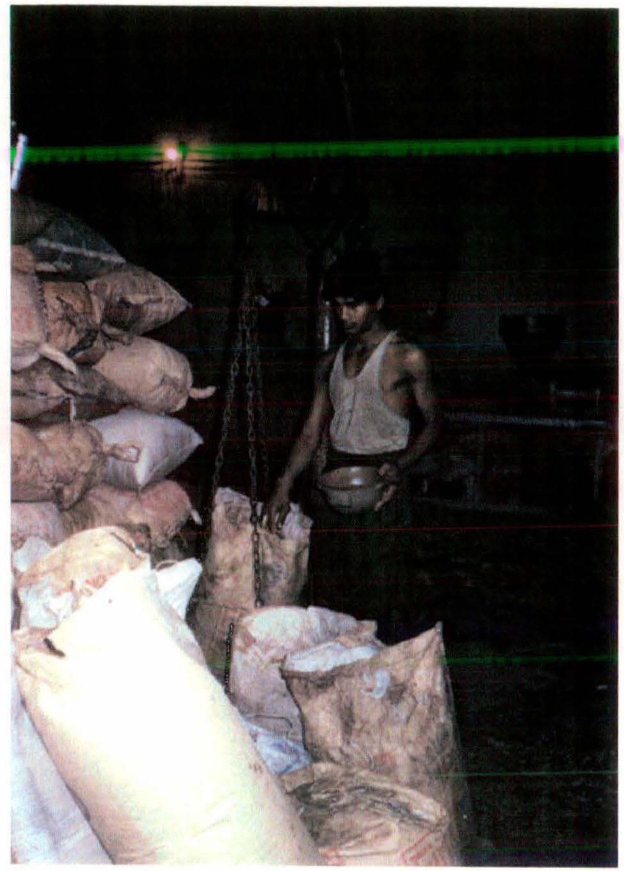
PLASTIC EXTRUDERS IN THE SMALL SCALE SECTOR



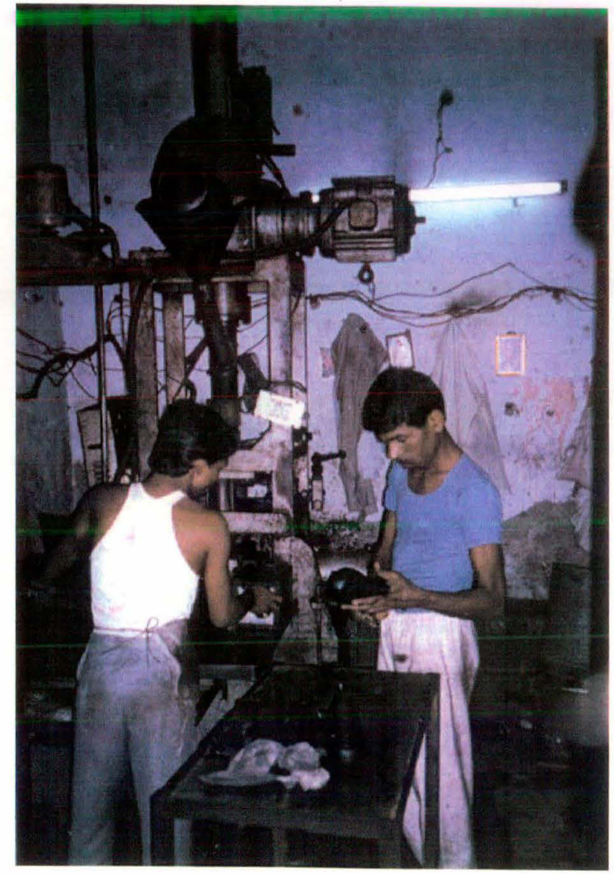


PRODUCTS

GRANULES



RECONVERSION

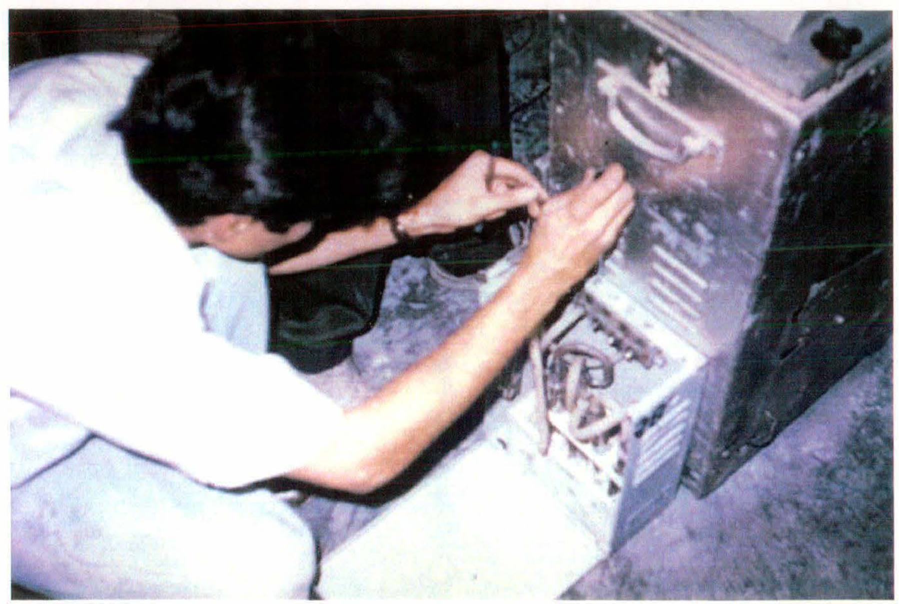


SECONDS ARTICLES

AIR QUALITY MONITORING IN PLASTIC REPROCESSING UNITS

GETTING READY TO GO

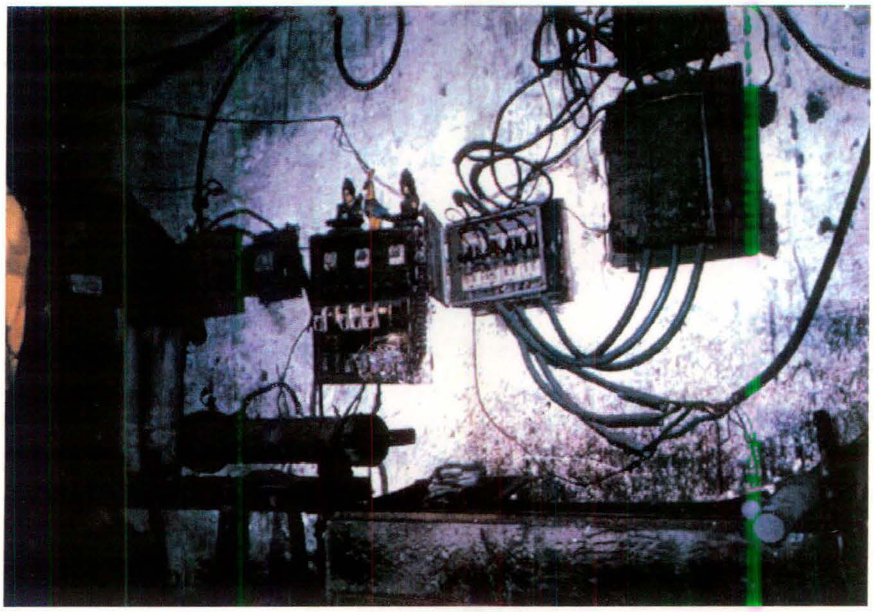
HIGH VOLUME SAMPLER FOR MEASURING DUST



LOW VOLUME SAMPLER FOR MEASURING OTHER INDOOR AIR QUALITY PARAMETERS

HAZARDS IN PLASTIC REPROCESSING UNITS

TAKING TEMPERATURE OF MOLTEN PLASTIC INSIDE EXTRUDER USING DIGITAL THERMOMETER



UNPROTECTED WIRING; TEMPERATURE CONTROL OF EXTRUDER ONLY BY KNOBS TURNING ON OR OFF; NO TEMPERATURE PANEL

DISCUSSION

Delhi has a road area of 1483 sqkm with a population of 9.42 million (according to 1991 census). According to the Directorate of Small Scale Industries, there are over 50 000 registered small scale and service operations in Delhi and many more which are unregistered and are functioning in sheds in residential localities or in urbanised villages under the guise of a flour mill etc.

There are 929 Jhuggi Jhompri (JJ) clusters, 44 resettlement colonies and 1000 unauthorised colonies wherein live a population of 15 lakhs each, while another 10 lakhs each live in slums and inside the congested walled city (The Hindu Survey of the Environment, 1995). The absence of clear policies on low cost housing to address, specially, the needs of the ever increasing migrants into the city has created such large settlements across the country that the sheer magnitude of the settlements now inhibit the formulation of any alternatives (Venkateswaran, 1994).

Involving the retrieval of recyclable items from mounds of refuse or dirty street sides, it is not surprising that waste picking finds its place at the bottom of the social hierarchy of activities within the informal sector. Despite this status, it is commonly adopted as a survival mechanism, linking in the process, the distinct situations created by adopting a specific development/growth path. For on the one hand, this activity is born out of a complete absence of options and a desperate need to survive in an overwhelmingly overcrowded labour market; and on the other, deflecting resource which create the need for recycling coupled with inadequately provided public services create the scope for such an activity (Venkateswaran, 1994). Contrary to common belief that women and children, who comprise more than 60% of the urban population, do not constitute any significant percentage of work force, the informal sector, in fact, includes a high percentage of both women and children.

Ragpickers are exposed to some specific health hazards owing to their occupation (Planning Commission, Government of India, 1995).

It is indeed well known that ragpickers because they pick waste from garbage and from dumpsites are prone to numerous infections and infestations from coming into contact with garbage which contains animal and human excreta , sputum, dead animals and potentially infected hospital waste dumped in refuse dumps. Infection of the skin, respiratory tract and gastro intestinal tract are reported to be more common among ragpickers than controls from the same socioeconomic group (Government of India, 1995). Similarly, gastro intestinal infections because of eating stale or spoilt food found in the garbage is also quite common among ragpickers.

However, chemical poisoning including pesticide poisoning because of coming in contact with empty containers of chemicals or using these as containers for food or water, or burning such containers as a source of warmth in winter although reported, have not been noted for their significance and connection with plastic waste especially the type of contaminated plastic waste that has been discussed in this study. Several anecdotal pesticide poisoning cases have been documented in children who have used discarded pesticide plastic containers as a glass for drinking water; lead poisoning in families where discarded lead acid battery containers were used as fuel. These have now been documented and noted for the dangers that can occur from contaminated plastics

Rat bite, snake bites, dog bites and bites and stings from other vermins and insects are common among ragpickers who scavenge in the refuse dumps but injuries, cuts and bruises of the hands and feet by sharp objects in the refuse also occur frequently. If these injuries are not treated they can lead to non-healing ulcers. HBV and HIV as well as a host of bacterial infections may occur if they get injured by contaminated sharps from hospital wastes.

They already have higher rates of skin and respiratory allergy because they are exposed to chemicals in refuse dumps. Setting fire to reduce volume of garbage, very often done by the municipal staff, causes the release of toxic fumes such as dioxins and furans especially if there are plastics such as PVC or chlorinated polyethylenes in the garbage. 45% of plastics manufactured and used in India consists of PVC (Malhotra, 1994) and almost 80% of hospital disposables from general hospitals is made of PVC (WHO, 1983) . In most of the cities in India, where there are large hospitals, plastic disposables are thrown in the hospital backyards to be searched for 'useful' material by contractors who employ ragpickers to sort out such waste. Very often, hospital wastes are sought after by ragpickers because that is among the only high value items that are left for them to pick up. Sometimes even the hospital staff such as ward boys segregate unscratched syringes etc. for selling to agents for repacking and selling in the market as new (Malik, 1996). Many of the hospital acquired infections are not something that can be washed by just soap and water (if at all they are washed) nor ordinary heating at 100 or 120 C can kill all the spores and viruses. Thus, contaminated plastic waste are a source of nuisance and grave danger to society and a separate policy to manage these wastes needs to be formulated and implemented at the earliest to prevent many more accidental deaths from occurring from such careless disposal and callous handling.

Another major area of worry is concerning the occupational health problems of sorters, the majority of whom are women. Sorting of plastic waste is manual in India as in many other countries. Although, there are several methods described for sorting plastics according to their density, using water, salt water, mixture of water and alcohol at different densities (Malhotra, 1994), to separate PVC, PS, HDPE, LDPE and PP, sorting all these types of wastes is being done manually and with bare hands. Furthermore, strange and dangerous techniques are being used for separating the non-plastic portion or different types of polymers fused together. For instance, cloth or rexine 'uppers' from PVC soles are separated by the sorters by turning them on open grates fired by cowdung cakes to soften and release the soles. The area of sorting is thus not only filled with smoke from cowdung fires but smoke and fumes from PVC too are released into the immediate work environment of the sorters who are often accompanied by their infants. Inhalation of large quantities of gases which dissolve to form acids (eg. NO , and Cl) might cause macrophage injury, but these substances are potent oxidants. Inhalation of gases to a degree sufficient to cause direct acid injury to the alveolar macrophages might be expected to cause severe generalised pulmonary parenchymal injury with little selective effect on the macrophage. Metal fumes, particularly cadmium, can impair macrophage metabolism and the emphysema produced by chronic cadmium exposure might be partially mediated by effects on the alveolar macrophage (Witschi et al, 1982).

Although, the air quality monitoring experiments conducted in five plastic reprocessing units in Delhi did not reveal the presence of Vinyl chloride monomer or HCl in PVC reprocessing units probably because PVC was not heated to very high temperatures, situations wherein polymers are heated to very high temperatures, is not uncommon. For instance it was observed in most of the units which were melting used, discarded carrybags (film waste), the temperature of the extruders was very high, although there being no temperature control panel, temperature inside the extruder could not be determined. However, from the charring that was taking place of the polyolefins and from the smell and the smoke, the temperature was gauged to be quite high. Smoke formation and carbon monoxide emission in thermal oxidation of waste, regenerated and virgin polyethylene show that the amount of smoke and CO increased with increasing crystallinity. The increase in CO concentration, during smouldering at 400 C was maximum for waste polyethylene and minimum for regenerated polyethylene. Maximum amounts of smoke and CO were formed below the autoignition temperature (Krasnikov et al, 1985).

Similarly, polystyrene too degrades very quickly on heating and at any temperature, there is a definite styrene concentration that can exist in the polymer at equilibrium where the polymerisation rate equals the depolymerisation rate; at 300 C styrene concentrations as high as 0.5% exists in equilibrium with the polymer(Crompton, 1979). Styrene, according to the Environmental Health series of the WHO, has adverse effects on cardiovascular, respiratory, endocrine glands and is also carcinogenic in fairly low concentrations especially if the exposure is for long periods of time. In many of the polystyrene based plastic reprocessing units like PS, HIPS, EPS etc., the waste polymer is heated to fairly high temperatures again causing charring and the agglomerate or 'gulla' in local parlance is then re-extruded into granules.

Investigations have also shown that in recycling LDPE, viscosity increased and melt index decreased significantly for LDPE after 3 processings. Rigidity and hardness increased through the 12 th recycle. Stabilised LDPE had higher resistance to stress cracking. Stress cracking increased with storage time (Varga et al, 1977). Therefore any polymer after a certain number of recycling and reprocessing will degrade and would have to be disposed. Thus highly plasticised recycled polymers can leach out the plasticisers as in the case of PVC. After leaving raw milk at 38 C for 4 hours in contact with PVC, bis-(2 - ethyl hexyl) pthalate or phenol or cresol alkanesulphonate (depending on the plasticiser used) were determined in the milk (Crompton, 1979).

It is well established now that toxic principles from contaminants get into the polymer and cannot be washed by soap and water or soda (Scott,1976). Therefore, such contaminated waste should be kept aside and may be used for either making structurals in a way that there is no human contact with the contaminated polymer or treatment of them to obtain fuel oils may be a useful extruders was very high, although there being no temperature control panel, temperature inside the extruder could not be determined. However, from the charring that was taking place of the polyolefins and from the smell and the smoke, the temperature was gauged to be quite high. Smoke formation and carbon monoxide emission in thermal oxidation of waste, regenerated and virgin polyethylene show that the amount of smoke and CO increased with increasing crystallinity. The increase in CO concentration, during smouldering at 400 C was maximum for waste polyethylene and minimum for regenerated polyethylene. Maximum amounts of smoke and CO were formed below the autoignition temperature (Krasnikov et al, 1985).

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In the present preliminary investigation, the plastic reprocessing and the equipment did not show up any major problems although the hygienic conditions of most of the units was very poor. In many units the equipment was old, dirty and run down, and the wiring was unprotected. Most units also stored the waste to be processed in the same shed and the sorting operations being carried out inside the same shed or room constituted a major fire hazard. However, detailed investigations into the air pollution hazards besides energy consumption needs to be done. Similarly, detailed investigations into the contaminants leaching into the food or beverages kept in such degraded plastics need to be studied. The levels of particulate matter in all the units investigated were very high, ie. above the standards prescribed in The Factories Ammendment Act, 1987. This is because of the level of dust in the waste and also the process of grinding the polymer which puts excessive dust into the atmosphere. Such processes and problems of dust allergy also need to be investigated and better methods of collection, storing and size reduction need to be evolved.

One very interesting observation that has come out of this study is as follows:

Generation of solid waste in Delhi is 6000 metric tonnes per day according to the MCD, NDMC and CDC put together. It is also known by quantification (NIUA, 1995) that percentage of plastics in Delhi garbage is about 2 to 3% as is all over the country which means that Delhi generates about 150 tonnes of plastic waste every day. In the present investigation, about 300 plastic reprocessing units were visited which were by no means all the units in Delhi. The method of sampling and estimation suggest that it was approximately 10% of the units present in Delhi. Even if the entire plastics waste generated in Delhi were to be recycled (estimated percentage of recycling by NCAER is 37 to 40%), just those ie, 300 units would be able to do the job, as each unit handles about 500kgs per day. Yet there are ten times the number of units in Delhi. Accepting that a lot of plastics waste comes from other parts of northern India to Delhi for recycling as survey indicated, there would still be quite a lot of unutilised capacity. Indian consumption of plastics being about 2kgs per capita per annum, the demand is about 2 million tonnes per annum.

Of this consumption, even if 40% is being recycled as indicated by NCAER, India would at the maximum require about 2000 tonnes of recycling capacity per day. At 100% recycling India would require a capacity of 5000 to 6000 tonnes per day. However, more than 20 000 units in India are presently reprocessing more than 10 000 tonnes of plastic waste every day. The units are not idle and nor is there underutilisation of capacity. In fact most units are running more than 12 hours a day. So, does this mean that India is reprocessing a fairly large amount, almost 50% of its recycling capacity, of imported plastic scrap?

CONCLUSION

An assessment of the life cycle of plastics waste in the Indian context has been attempted. It can be said that plastic reprocessing in India is still being done in a very unguarded way and detailed investigations regarding the effects on health of every aspect of the recycling chain needs to be undertaken. Several improvements have to be carried out before we conclude that we are good recyclers or resource managers.

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APPENDICES

Appendix 1

Interview schedule for ragpickers used during the survey tour in July - August 1995

Interviewer's name:

Place of interview:

Date of interview:

Name of Ragpicker : Age : Sex:

Father : Alive / Dead Mother : Alive /Dead

No. of family members:

Education and professional details : Whether attended any school before?

How old he/she was when entered this profession?

How much waste do you collect per day?

Do you pick up plastic wastes? If yes, what type and approximate quantity?

How much do you sell your waste at? to Whom?

paper —— aluminium ——————

plastics —— glass ——————

metal ——— other ——————

bottles —————

Do you get any help from organisations ? Financially, Educationally, Socially?

Do you have any specific preference of plastic waste ?

Do you get better price if you look for a certain type of plastic?

Which according to you is the type of plastic waste that is easily usable and reusable?

Do you have health problems? Is it because you work with garbage ? Have you tried using some of these plastics for covering your hands head etc ?

Appendix 2

Interview Schedule for Kabadiwalas (itinerant waste buyer) and petty buyers used during the survey tour in July - August 1995

Name of the interviewer:

Date of interview :

Place of interview :

Name of Kabadiwala : Name of Shop if any:

How many ragpicker sell their waste to you? At what rates ? Plastic

Glass

Metal

Do you help the ragpickers financially, socially?

Do you buy plastic waste? At what rates?

How much of plastic waste do you get per day?

Which type of plastic is most common? Is it good for the environment? Is it being recycled?

Which type of plastic waste fetches maximum price in the recycling market and why?

Do you have any health problems because you are working with garbage?

Do you have to segregate a typical type of waste or plastic waste to get a better price?

Who segregates the waste? Do you have sorters in your shop? How many? How much do you pay them?

What about householders ? Do they segregate their waste plastic before selling to you? Which type plastic waste do you get maximum from households, shops, offices etc.?

Appendix 3

Inetrview schedule of Owners of units reprocessing plastics in Delhi

Interviewer's name : Industrial area:

Date of Interview : Name of the unit: Address :

Contact person :

Basic data :

Type of unit: Type of waste: Qty.of waste:

Rate of waste /kg Place from where waste got: Source:

Number of workers: M / F/ C Employees:

Scale of unit : Wage 1 / Wage 2/ Wage 3 Electrical connection :

Elec.bill : Processing cost/kg Taxes : Other cost :

Product type1: Product type 2: Product type 3:

Rate 1 : Rate 2: Rate 3:

Production/day (kgs) Unit dimension :

Equipment 1 No. Equipment 2 No. Equipment 3 No.

Equipment 4 No. Equipment 5 No.

Environmental Data:

Scrap stored in : Scrap sorted in: Whether scrap contaminated:

Scrap sorted according to: Type of sort:

Scrap wash: Scrap Dry in: Wiring of unit:

Whether temperature control: Heating elements in Extruders:

Wall height : Doors: Windows: Ventilators: Exhaust fans:

Exhaust vent: Blower fan: Product stored in:

Marketing: Chemicals used in processing and washing: Type of colours:

Condition of unit: Condition of Employees: Air quality: Water Quality:

Appendix 4

Proposed Guidelines for Reprocessing of Plastics for use of organisations like the Bureau of Indian Standards

As outlined earlier, reprocessing of plastics could be taking place at different stages in the life-cycle of plastics. During the manufacture of resins from raw material, there could be wastage which could be reprocessed along with fresh material; subsequently when consumer products from virgin resins or compounded material are made, there could be wastage or off-quality products which can be reprocessed in the same plant or they may be sent to small scale reprocessors where they may be regrantulated and sent back to the manufacturer for making seconds products or for mixing with virgin material to reduce cost. These granules are generally referred to as 'semi' and considered almost as good as virgin. However, if they have been sent to small scale reprocessors who have primitive extruders with no temperature control facilities and inefficient extrusion mechanism, then the material undergoing reprocessing would suffer some amount of degradation and cannot be considered to have the same properties and qualities as virgin products. The third situation which is the most difficult one, consists of reprocessing post-consumer plastics which have been bought and collected from homes, offices, shops and institutions or picked from roadside bins, gutters and dumpsites by ragpickers and sold to agents for a small amount. These post-consumer wastes are traded from all over the country in main centres like Jwalapuri in Delhi, in Dharavi in Bombay and in Calcutta besides smaller amounts in Bangalore, Madras, Ahmedabad and several other cities and towns in India.

These reprocessing units are small/tiny units in sheds and small rooms of dimensions ranging from 60 to 100 or 200 sqft. often within residential colonies with 12 to 15 HP connections enough to run agricultural pumpsets and a small flour mill. In fact most of these units being in the outskirts and peripheral villages are registered as agricultural connections and the rate at which electricity is paid for is by the agricultural rates ie. 50 paise per unit rather than Rs.2.00 per unit as small scale units are required to pay. In fact many of the reprocessors do not pay any electricity bills at all and straight away pay a fixed amount to the electricity department employee and run their units through night and day while there is electricity. The machinery is all completely local and quite primitive with no temperature controls or any other quality control measures. Therefore even products made from virgin polymers may have undergone some extra stress and with inferior quality colours and additives cannot be said to be of first grade, least of all food grade but unfortunately many household items that we buy are made by the tiny industries sector whose capital investments is about 2.5 to 3 lakhs and with another working capital of Rs. 50 000 or 1 lakh, the units may be earning net profits of Rs. 50 000 to 1 or 2 lakhs per month. Therefore, we have to be cautious that what may appear as an economic activity to all of us, may be doing great harm to human health since neither can they be included among small scale industries nor brought under any pollution control measure for lacking infrastructure .

The machinery required for reprocessing is almost of the same type as required for processing of virgin plastic pellets. In the case of the reprocessing industry, an additional grinder with blower is necessary to grind the waste plastic into small pieces and free it from dust by blowing on it. In cases when High Density Polyethylene (HDPE), Polystyrene (PS) or Low Density Polyethylene (LDPE) bottles or containers have to be reprocessed into granules, the containers are ground, then washed with soap or plain water, dried first in an equipment called 'hydro', then dried in the sun and reprocessed. In these cases as in others, sorting is always done according to colour and according to blowing or moulding quality. More colours if necessary are added during the process of dry blending (in the case of PVC, chemicals and plasticisers are also added) where the mixer blades by their rotary action generate heat which helps the plastic to soften and blend with the colour and chemicals. The softened and blended material is then fed into the extruder where, by heating to temperatures above melting points with heating elements stuck into the extruder tube with screw, the melted plastic is extruded and emerges as thin or thick strands through metal filters with holes of varying thickness from 20 to 80 microns. The extruded strands of uniform thickness are cut into small pellets or granules which are sold again to blowing or moulding units or consumed by units themselves which have both extruders or other moulding machines.

All these types of equipment, including grinder, mixer, extruder, cutter and even blowing and extrusion machines are made in Delhi and in several other parts of India. These tiny units more than 20000 of them in different industrial estates in India, are under the protection of influential people and hardly pay any taxes, some of these units run even with licences for agricultural pumpsets, pay very less for electricity, observe no pollution control or human safety measures. They have a turnover of 0.5 to two tons per day, run two to three shifts in a day which is 12 to 18 hours and are restricted only by the availability of electricity. The reprocessed granules are sold at prices ranging from Rs. 12 or 13 per kg for PVC (Polyvinyl chloride) soles to as high as Rs. 40 per kg for high quality medical or food grade LDPE waste reprocessed granules. Approximately Rs. 1 to 2 per kg is spent as processing cost, another Rs.1 per kg as maintenance, rent etc. expenses and the profit margins are more than 2 to 3 rupees per kg on an average thus giving net profits of Rs. 30000 to 60000 per month to the owner of the unit which produces about 20 tons per month. Some units which are larger, earn more by reprocessing industrial waste which they collect directly from the industries thus avoiding the extra expenditure of buying from agents, sorting, cleaning etc. They may get the waste cheaper or more expensive but have to pay for the transport, unloading etc. They prefer this especially if there are large industries in the vicinity of their units since the waste is relatively clean and of one type and one quality only. These units have slightly higher profit margins and produce fairly high quality granules which are sold as 'semi' and often used to mix with fresh pellets or granules to reduce costs and economise on production costs of materials being made from virgin plastics. Some medium scale industries, processing virgin plastic polymers also send their industrial waste, to be granulated in these small industries, on job work basis, which they later use for processing into non-foodgrade applications.

Various qualities of PVC granules are sold to PVC 'chappal' or shoe making small scale units which make chappals or shoes from both virgin PVC and seconds, but especially during monsoons, PVC chappals and black school shoes for children are made from recycled granules mostly extruded from melting old PVC chappals and shoes. Similarly, granules made from broken, fresh or reprocessed PVC pipes and cables are re-extruded after adding suitable plasticisers and fillers to again make pipes, cables or tarpaulins.

Most common among the reprocessed articles made from waste plastics are the ubiquitous carrybags which with suitable mixing of blow quality HD and LD granules are blow extruded into thin film tubes which are then sealed and cut on one side to give carrybags of the HM variety, as they are called, and are sold in the market at Rs. 32 to 36 per kg for coloured and Rs. 38 per kg for white or milky variety. These bags circulated through vegetable and fruit vendors undergo several reprocessings until they are finally heated to high temperatures, mixed and charred to give black lumps which are then blown into black colour jerry cans and containers for storing a variety of items including inorganic acids, invert sugar syrup, vegetable oil, ghee or even drinking water. Large overhead tanks black in colour from non standard companies could also be made from such charred lumps.

Granules made from high density or low density polyethylene of the blowing quality are often carefully sorted, granulated and reblown into bottles, containers, toys etc. HDPE, LDPE of the moulding quality are granulated and moulded back into several types of household articles which find their way back into our houses through one or other route. Although this seems to be a good method of conserving resources and energy, there are several issues connected with this type recycling which involves making of food grade or human contact grade of products from inferior quality plastics which are definitely no longer of the food grade or human contact grade. This is so, especially, after they go through the whole cycle of discarding, picking, sorting, grinding along with so many other kinds of containers many of which may have even contained toxic substances like motor oils, paints, cleansers, distempers and pesticides. Even if the containers are sorted according to the original contents, never mixing containers of toxic substances with those of food type containers, the habit of reusing the containers for various purposes before discarding, which is very widespread in India, may still contaminate the containers and render them unfit, for processing them back into food grade containers. Besides, once the plastics have been kept for sometime especially to store oils etc. and are also reprocessed into granules in reprocessing extruders with hardly any temperature controls and, then colours added which may not be of the food grade or meant for containers for storing water, the products made from such granules cannot be considered as safe for food or other human contact purposes.

Units which make use of granules made from Acrylonitrile-Butadiene-Styrene (ABS), Polystyrene (PS) or High impact polystyrene (HIPS), for making TV and cooler cabinets and other such structural articles can be said to be conserving resources although the process of melting ABS, PS or HIPS in extruders without much temperature controls can give rise to styrene fumes which are toxic and can affect the workers adversely. Thermocol packaging and cups made from HIPS also give off toxic styrene fumes when they are burnt to make small lumps, which are added to other HIPS scrap to give 'shine' . Similarly polypropylene (PP) too gets reprocessed to be made into inexpensive moulded luggage. In all this, very little or no attention is ever paid to quality of the products made, which of course never conform to ISI standards but are often so flimsy that they break and are discarded again to be picked up and reprocessed. Thus we see carry bags of the reprocessed quality flying about, because they have become so degraded that even the ragpickers do not care to pick them and hence these find their way in to drains where they choke the drains and cause explosion or are burnt in the open letting off noxious fumes which may even cause fires or death due to toxic fumes. Extremely poor quality PVC cables with high quantities of plasticisers and fillers start exuding the substances especially at higher ambient temperatures thus becoming responsible for the large number of fires that have now become commonplace in tall buildings, marriage halls and even during functions with temporary electrical connections. Poor quality irrigation and conduit pipes of reprocessed PVC can also cause accidents and loss of money and resources.

Fused and inseparable double layered or triple layered thin film packaging (such as in pan masala pouches) are extremely harmful to the environment because they are either discarded, burnt or acids and chemicals used without any protection to humans or environment to separate the layers, are discarded in the environment. We would do well to restrain the packaging industry from promoting such environmentally unsound material and institute some disincentives by not giving the ecomark to such type of packaging.

PET or Polyethylene terepthalate waste still does not have very wide market and is being reprocessed by only a few reprocessors since it cannot be easily melted and extruded like other plastics and the cracking technology for breaking it down to molecular level requires too much energy, capital equipment and high technology and hence it is not possible to reprocess it in the small or tiny sector. However it is believed that even PET waste is being reprocessed by selected few in India to convert it into fibres or moulded items.

A lot of imported waste especially LDPE, LLDPE etc. are being granulated and used up in India and there is a great demand for such 'high quality' waste including polycarbonate crushed containers and powders from Middle East and developed countries. However, in the garb of importing good quality polyester and polycarbonate waste some unscrupulous importers, at times, import plastic containers and car batteries along with Copolymer containers of car batteries along with the entire toxic contents. Thus there is dire need to regulate the import of scrap.

Thus there are several kinds of plastic wastes and several different issues ranging from escape of HCl from PVC, styrene from PS, HIPS, ABS etc. to SO2, NOx, CO and CO2 emissions coming out of not only PVC reprocessing factories but also from other plastic wastes reprocessing factories, causing 'Sick Building Syndrome' (SBS) and pollution of the external environment besides fire hazards due to improper storage of waste, accidental or deliberate burning of plastic waste and several others pertaining to quality and quantity of waste being reprocessed. Not only the products being made from waste but also the type of waste itself being reprocessed need to brought under some control and monitored. To this end, the Indian standards for plastic waste recycling makes the following points mandatory:

1. Quality of raw material used in the production of reprocessed/recycled compound/granules :

(a) tensile strength, colour, smell, thermal stability, loss of mass, ageing and other parameters applied to materials of ISI specifications

(b) materials used in compounding (type, quality and quantity of chemicals) and their reprocessing

(c) quality of waste used as raw material for preparing the granules/compound since the contamination and dust in the raw material can be passed on through the granules to the products;

d) toxic colours that are being used to colour granules prepared from reprocessing waste plastics including Lead and Chromium based pigments and powders which can be harmful to human beings not only through items used for storing food or water, but through other items such as shoes and bags which are in direct contact with our skin . Furthermore, white or other light colours in reprocessed granules is achieved by sorting and processing white or 'natural'(transparent/translucent) colured containers or bags separately. This camouflages their true nature. Therefore, care should be taken not to permit white, natural or light colurs to be used for packaging motor oils, pesticides, cleansers, detergents, paints and other toxic substances even at the first instance because there is every chance that the toxic principles in these contaminated containers will be passed on into the granules once the waste is reprocessed for making other products. All products which are harmful to human or general environment should be packaged only in dark or dull colured containers or packings so that even if they get reprocessed, they will remain darkly coloured and cannot be passed off as virgin material because of their white colour, transparency or translucency.

eg. (i) HM carry bags made from granules which have been compounded by grinding bags or containers storing DDT, BHC etc. not only smell of the pesticides but would have residues of the chemicals in them rendering them totally unfit for using them for storing food and liquids for human consumption and for other human contact purposes.

eg. (ii) white or lightly coloured containers used for packaging Chyawanprash etc. are often made from reprocessed granules made from other white or light colour containers which are being used to package such material as mobile oil, 2T oils, paints, cleansers, distempers, detergents and pesticides which would have toxic principles in them.

2. Quality of process used for preparing the compound/granules :

(a) Washing of HD, PP, PS/HIPS, LD etc. with simply water or soap solution may be sufficient for preparing granules for making inexpensive attache cases and TV cabinets but would not be sufficient for preparing granules for making containers which would hold food, water or medically safe or sterile substances. Therefore, care should be taken not to allow manufacture of such containers from waste or reprocessed granules or lumps as those that may be used for holding material for irrigation of crops, or for human or animal consumption.

(b) Age of equipment and temperature control mechanisms play a very vital role in determining the quality of the product that emerges from such equipment. Most products of food grade or those made for highly sophisticated use including medical applications are made from virgin plastic resins. Most of the polymers, require precise temperature control for moulding, which is specified by resin manufacturers. However, these thermoplastics, when reprocessed, at fairly high temperatures or by processing equipments having poor temperature control mechanisms, the finished products have inferior properties. This is probably one of the reasons behind the inconsistency of products even with ISI certification.

(c) ISI specifications clearly specify the type of colours and additives that can be used for food grade, medical grade etc. of plastics and polymers. However, manufacturers making products even from virgin plastics, for use in food packaging, are unaware of these specifications. Even fluorescent colours are being used for containers and products meant for food or water storage or distribution. Master batch colours with ISI specifications are expensive and rarely ever used for colouring reprocessed granules. Furthermore, to hide the dullness of plastics due to reprocessing and bring gloss to the products, not only excessive use of colours is resorted to but even other additives are added to the polymers , which are responsible for reducing the quality of the compounds thereby rendering them unsafe and dangerous.

eg. Electrical wiring using PVC for insulation, sheathe, conduits etc. can be prepared with more than recommended quantity of chlorinated paraffin wax (CPW) which gives a lot of shine initially but since the wax tends to ooze out after a while and the electrical wiring becomes hard, this kind of compounding is likely to cause short circuiting and fires. This kind of misuse of compounding procedures occurs even in the preparation of virgin finished products and is most common among reprocessed granules preparation.

(d) Fumes and emissions from reprocessing plastics under unregulated conditions could affect the quality of products but in addition they affect the environment in which the reprocessing is done thereby making the product ineligible for 'ecomark' which require that not only the products be safe but the conditions under which the products are manufactured are not harmful to the environment.

3. Quality of environment - ecomark can be awarded to items or products only after studying the lifecycle of the product or process in question.

(a) although recycling as such may be an eco-friendly concept, how recycling is actually carried out and whether the process may actually be more harmful to the environment needs to be considered before 'ecomark' or 'eco-friendly' mark is awarded to any product or process. Removal of waste plastic from the environment cleans the environment but such waste to be first discarded in dustbins, gutters and dumpsites where they are contaminated by unhygienic waste and then to be picked up from there and reprocessed in to granules for making such things as even carrybags or toys cannot make it eligible for the 'eco-mark' since thin films collected from roadside dustbins or dumpsites are only dusted before reprocessing, never washed. If waste plastic, even thin films, have to be made use of for reprocessing, they should be separated at source and collected in a hygienic way and then reprocessed under prescribed regulations keeping in mind the quality of the polymer and the final application besides temperature, emissions and effluents from the processing.

(b) Workers at the sorting places are mostly women - adult and children, who use no protective devices for preventing either dust inhalation, contact dermatitis, erosion of ophthalmic or nasal membranes or accidental infection or poisoning from cuts and abrasions. Although the concept of reprocessing shoes back into shoes or slippers may seem eco-friendly, it was seen that for separating the PVC soles from the uppers, crude grates fired by cowdung cakes are used and women and young children lean over these polluting contraptions to keep turning the shoes like chappathis to soften them and release them from the soles. Such processes cannot be termed as environment-friendly because they not only degrade the polymers but also generate toxic and pungent fumes from HCl and SO2 to CO, CO2 and others harmful to both human and the general environment.

(c) Collection and sorting of hospital and other types of infected waste is being done at present in India in a most appalling manner which is extremely harmful and dangerous to human health and the general environment. While IV (intravenous) bottles made of low density polyethylene(LDPE) or polypropylene(PP) may be washed at least with water before being reprocessed, PVC tubes and blood bags used for intravenous or other interventional procedures stained with blood and other body fluids are being sorted by young children of less than even 14 years, with bare hands, and reprocessed without even washing or cleaning into all sorts of products directly or indirectly in contact with the human environment.

(d) All the sheds and enclosures either storing, sorting or reprocessing plastics are health hazards or fire hazards because of the high inflammability of the plastics and the fumes emerging from the melting, burning or charring of such plastics can cause irreversible damage to human health and the general environment. Acid fumes, Dioxins, Poly aromatic hydro carbons and other carcinogenic and teratogenic substances can come out of the plastics when they are burnt accidentally or deliberately endangering the health of not only the workers carrying out the sorting, reprocessing etc. but even others in the near vicinity since the smoke emerging from such collection markets and factories spreads slowly and at fairly low altitudes. Thus regulations for ambient air quality monitoring inside and outside all storage, collection and trading centres and reprocessing factories is a must and regular pollution checks of air and water samples from these centres is required for maintaining the safety of all those involved with waste collection and processing and the rest of the community who are not directly involved but may be caught unawares due to the callousness and careless attitudes of the waste industry. Regulations for temperature control, pollution control, size of shed, safe electrical installations inside the sheds or near storage dumps, ventilation, age of equipment and training of workers to prevent and handle accidents are some of the steps required to make the reprocessing of plastics safer.

(e) Since the sorting of plastics is done manually in India, mostly by illiterate persons who have perfected their skill by practice alone, marking of each type of plastic as suggested by international coding systems would be useful, but in addition, some sort of coding by Symbols etc. would definitely help in segregating the plastics at source and at the point of sorting. This would also help in preventing the reuse of wrong type of plastics thereby protecting the plastics and the environment from contamination and degradation.

Lastly it can be said that education and awareness building among the public regarding the usefulness and limitations of plastics would go a long way in safeguarding the health of the public and prevent misuse and abuse of plastics and prevent accidents and harm to the environment. Public should be educated that all types of plastics cannot suitable for all types of uses; for instance hard PVC mineral water bottles and PET containers may be alright for reuse to store water or food but HDPE chemical containers should not be reused for storing or carrying food or water and hot or pungent liquids should not be stored in any of the above type of bottles or containers. HM carrybags including recycled ones are being used in all parts of India, for packaging food and liquid meant for human or animal consumption especially spicy and hot (temperature) substances . This practice should be campaigned against and severely penalised in case of hotels and restaurants resorting to such harmful practices. Public awareness and education is very important regarding several issues such as unnecessary and wrong use of plastics, necessity of segregation of plastics, prevention of contamination of plastics while using, storing, disposing, recycling plastics and prevention and management of accidents occuring due to wrong use of plastics. Such awareness building activities should be taken up by the government, scientific institutions and non-governmental organisations (NGOs) and through the print and the electronic media.

Appendix 5

ASTM Designation : D4443 -84 (Reapproved 1989)

Standard Test Method for

Analysis for Determining Residual Vinyl Chloride Monomer Content in PPB range in Vinyl Chloride Homo- an d Co-polymers by Headspace Gas Chromatography

1. Scope

1.1 This test method is suitable for determining the residual vinyl chloride monomer (RVM) content of homopolymer and copolymers of vinyl chloride down to a level of 5 ppb.

1.2 This test method is applicable to any polymer form, such as resin, compound, film, bottle wall, etc. that can be dissolved in suitable solvent.

2. Referenced document

2.1 *OSHA Standard :*

29 CFR 1919.1017 - Vinyl Chloride

3. Summary of Test Method

3.1 Samples of vinyl chloride containing polymers are dissolved in a suitable solvent in a closed system.

3.2 The polymer solution and headspace are equilibrated at an elevated temperature.

3.3 Aliquots of headspace gas are injected into a gas chromatograph and the vinyl chloride monomer is separated. The response of vinyl chloride monomer is determined by the use of several suggested detectors.

3.4 Calibration is accomplished using either (a) vinyl chloride monomer in nitrogen gas standards, (b) standard solutions containing known amounts of vinyl chloride monomer, or (c) a method of standard addition.

4. Significance and Use

4.1 Vinyl Chloride containing polymers are widely used to package a variety of materials, including foods.

4.2 Vinyl chloride monomer has been shown to be a human carcinogen. Threshold toxicity value has not been established.

4.3 Plastic manufacturers, food packagers, government agencies, etc. have a need to know the residual vinyl chloride-containing polymers.

5. Abbreviations

5.1 *VCM* -Vinyl chloride monomer.

5.2 *DMAc* - N,N-dimethylacetamide.

6. Interferences

6.1 DMAc should be analysed to determine the absence of interferences at the vinyl chloride monomer gas chromatography (GC) retention time.

6.2 Other solvents, monomers, or compounding aids may cause interference at the vinyl chloride monomer GC retention time.

7. Gas chromatography, equipped with either a flame ionisation detector (FID), a photo ionisation detector (PID), or a Hall electroconductivity detector (HED), backflushing valve, and capable of either automatic (Note 1) or manual sampling (Note 2) and analysing the headspace vapours contained in a sealed vial.

Adventitious volatiles in polymers - Styrene

Gas chromatography

Due to their volatility and complex composition it is not surprising and complex composition it is not surprising that methods based on gas chromatography have emerged as being the most suitable way of analysing for these parameters. There are several approaches in the application of gas chromatography:

1. solution of the polymer in a solvent and injection into the gas chromatography;

2. heating the dry polymer and sweeping the volatiles released into a gas chromatograph using

the carrier gas;

3. head-space analysis, ie. heating the polymer in a closed system, then withdrawing the head-space with a syringe for direct injection into the gas chromatograph.

Source : Analysis of Polymers, T.R.Crompton, 1993

Heavy metals

m3/min) that allows suspended particles having diameters less than 100 microns to pass through the filter surface. Retention size : 100 - 0.1 microns

The mass concentration (microgram/m3) of suspended particles in the ambient air is computed by the mass of collected particles and the volume of air sampled.

Range and sensitivity : At rate 1.13 - 1.4 m3/min for 24 hours. Minimum detection limit is 1microgram/m3

Apparatus : High Volume Sampler 1.13 - 1.4 m3/min. Envirotech APM 415 (HVS)

- 10/8 inch GF/A filter paper
- EPM 2000 (for subsequent metal analysis)

Sampling procedure :

Inspected the filter paper for pin holes, particles and other imperfections. Both blank and samples were conditioned at 20 - 25 oC and relative density and humidity below 50% for 16 hours prior to weighing. Weighed the filter paper to the nearest mg and marked filter identification number. Installed the numbered and pre-weighed filter in position (rough side up). Replaced the face plate without disturbing the filter and fastened securely. (Under tightening will allow the air to leak, over tightening would damage the filter and sponge rubber face plate gasket).

Noted the temperature, initial and final flow rate and the time duration for which the sampler HVS Envirotech APM 415 was kept on inside the unit. The sampler was kept towards the centre of the room but close to where there was activity. In all the units except one, the samplers were kept on for a minimum of 4 hours.

After completing sampling in each of the locations on different days and periods, each time, the face plate and carefully removed the filter paper from the assembly. Folded the filter paper lengthwise so that only surfaces with collected particulates were in contact. Placed each time in clean polythene bags. Recorded filter paper number, location and other meteorological conditions etc.

Analysis : Conditioned each of the exposed filter papers for 2 - 3 hours at 105oC, then weighed.

Calculation : SPM (microgram/m3) = weight of dust collected in mg * 1000

volume of air (m3)

The results of all the units are given in a table along with other parameters in the Results chapter.

Ref: IS 5182 (Part IV) - 1973, CPCB emission regulation, part III (Dec. 1975); Chap. 6

Measurement of Respirable Dust Concentration:

The respirable dust high volume sampler designated as Envirotech APM 451 is based upon knowledge developed at NEERI, Nagpur, the CSIR lab. which first separates coarser particles (larger than 10 microns) from the air stream before filtering it on the 0.5 micron pore-size allowing measurement of both the TSP and the respirable fraction of the suspended particulate matter (SPM).

Procedure : Respirable dust concentration is determined gravimetrically which requires accurate weight estimation of the change in the weight of the filter on account of the respirable dust deposited on it. However the coarser particles are trapped in the cyclone assembly.

Calculations : SPM (microgram/m3) = weight of dust collected in mg * 1000

volume of air (m3)

Ref : ASTM, D4532 - 85, std.test method for the respirable dust in the work places.

Operating manual of the manufacturer of the RDS cat. - no. APM 451 (Envirotech)

Measurement of SO_2 (Sulphur dioxide) in ambient air

Specification IS : 5182 - 1969 (Part II)

Principle : SO_2 is absorbed in sodium tetrachloro mercurate (STCM). It is estimated by colour produced when p-rosaniline -HCl is added to the solution. Absorption is measured in a spectrophotometer and compared with a calibration curve already prepared.

Interference : O_3 and NO_2 interfere. NO_2 interference is estimated by 0.06% Sulphmic acid. Heavy metals especially Fe interfere, which is eliminated by adding EDTA.

Apparatus : Low volume sampler attached with HVS unit

Absorber : all glass fritted bubblers and impingers

Rotameter : 0 - 3 lpm (litres per minute) calibrated.

Cold box : bubblers are kept in insulated box.

Spectrophotometer used in these experiments - Systronics 106

Absorbance taken at 560nm for SO_2.

Reagents : Absorbing solution : 0.1 STCM (dissolve 27.2 g mercuric chloride and 11.7g NaCl in 1 litre distilled water).

-p-rosaniline HCl : (0.04%) acid bleached, 0.2 g solid + 100ml distilled water, kept for 48 hours. 20 ml of filtered solution + 6ml of conc. HCl . Colour of the solution is pale yellow with green tint.

- Formaldehyde solution : 0.2%

Sampling - sampling rate : 0.2 - 0.5 lpm

absorbent : 20 - 30 ml

Analysis : Adjust the absorbent volume with distilled water. 1 ml sample + 1ml p-rosaniline +1ml formaldehyde solution. Mix well. Prepare blank with 10ml of unexposed STCM.

Calculations : SO_2(microgram / m3) = slope * abs * vol. of absorbent * 1000

lpm * min (sampling duration

Range of detection limit 3 microgram /m3 for 240 litres air sampled

Ref: IS: 5181 (pt 11) - 1969, method no.2

Measurement of Nitrogen oxides in ambient air (modified Jacob & Hochheiser method)

Specification - IS : 5182 - (Part VI) 1985

Principle : Air is bubbled through NaOH solution to form stable sodium nitrite. Nitrite produced is determined colorimetrically with phosphoric acid,sulphanilamide & N (1, napthyl, ethylene, diamine dihydrochloride) - NEDA

Apparatus : - low volume sampler attached with HVS

- absorber : all glass fritted bubblers with impingers
- rotameter : 0 - 3 lpm,caliberated
- cold box : bubblers are kept in cold box containing cold water
- spectrophotometer : set 540 nm

Reagents : Absorbing reagents 4.0g NaOH + 1.0 g sodium arsenite in 1 litre distilled water

- Sulphanilamide : 20g sulphanilamide + 700ml of distilled water + 50ml conc. phosphoric acid, dilute to 1 litre
- NEDA, solution : 0.5g NEDA + 50ml distilled water
- Hydrogen peroxide : 1ml 30% H_2O_2 + 1 lit. distilled water

Analysis : To 10 ml of absorbent, add 1ml H_2O_2,
10 ml of sulphanilamide & 1.4 ml of NEDA. Mix well. Prepare a blank with absorbing reagent. After 10 min read absorbance at 540 nm

Calculation : No2 (microgram/m3) = slope * absorbance * vol.of absorbent * 1000
lpm * min (sampling duration) * 0.82

0.82 = overall collection efficiency factor

Detection limit : 10microgram / m3 for 96 lit. of sample

Ref : IS : 5182 (Part IV) - 1975,

CPCB, Emission regulation (Dec. 1985) pt. - 3, chap.7

Measurement of HCl/chlorides

Specification : IS : 10496 - 1983 (21- 23)

Principle : Colorimetric method (for low range)

Solutions of ferric ammonium sulphate and mercuric thiocyanate are added to sample. The chloride ion reacts with the mercuric thiocyanate to produce thiocyanate ion which in turn combine with ferric to form red ferric thiocyanate. The intensity of the colour is measured at the wavelength of 463 nm.

Reagents : 25 ml sample in distilled water was taken in a beaker

+ 5ml Ferrous Ammonium sulphate

a) 5 gm of ferrous sulphate [Fe(NH4)2(SO4)2 .6H2O] in 20ml water. Add 38 ml conc. HNO3 and boil. Cool and make the volume to 1000ml with millipore water.

+ 2.5 ml Mercuric thiocyanate solution

b) Dissolved 0.30 gm of mercuric thicyanate Hg (CNS)2 in 100mlof methanol. Store in amber bottle and allow to stand for at least 24 hours before using

c) Standard chloride solution. (10mg/l) ; prepared a stock solution by dissolving exactly 1.649 gm of the dry salt in water and dilute to 1 litre. Prepared the std. solution as needed by diluting 10 ml of the stock solution to 1 litre with water. The resulting standard contains 1.0 mg of chloride ion/ litre.

Procedure : Prepared a series of reference standards by diluting suitable volumes of the standard chloride solution with millipore water

- To 25 ml blank, standard and sample, added successively 5ml of FAS solution and 2.5 ml of mercuric thiocyanate solution . Mix thoroughly and allow to stand for 10 minutes.

Measured the intensity of colour at 463 nm & plotted a calibration curve and calculated the conc. of chloride in sample by slope.

Ref :1) IS : 10496 - 1983 (21 - 23)

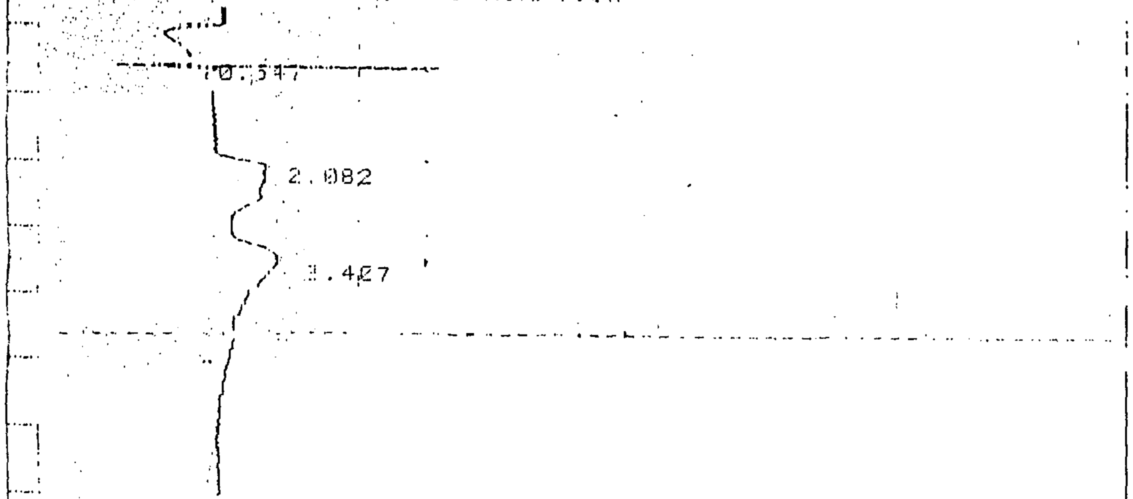
2) Standard Method for examination of Water and Waste water Ed 18, 1992, 4.48 - 4.52

MSD | 50 ml

50 ml of Sample

PVC
CABLE UNIT
VISHWASNAGAR

CHART SPEED: 1.0 CM/MIN
ATTEN: 1 ZERO: 5% 1 MIN/TICK



TITLE: VCM CONTENT 4:38 0 JAN 79

CHANNEL NO: 1 SAMPLE: METHOD: ASD

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	HEIGHT COUNTS	SEP CODE
		100.0000	0.510	271	VV
TOTALS:		100.0000		271	

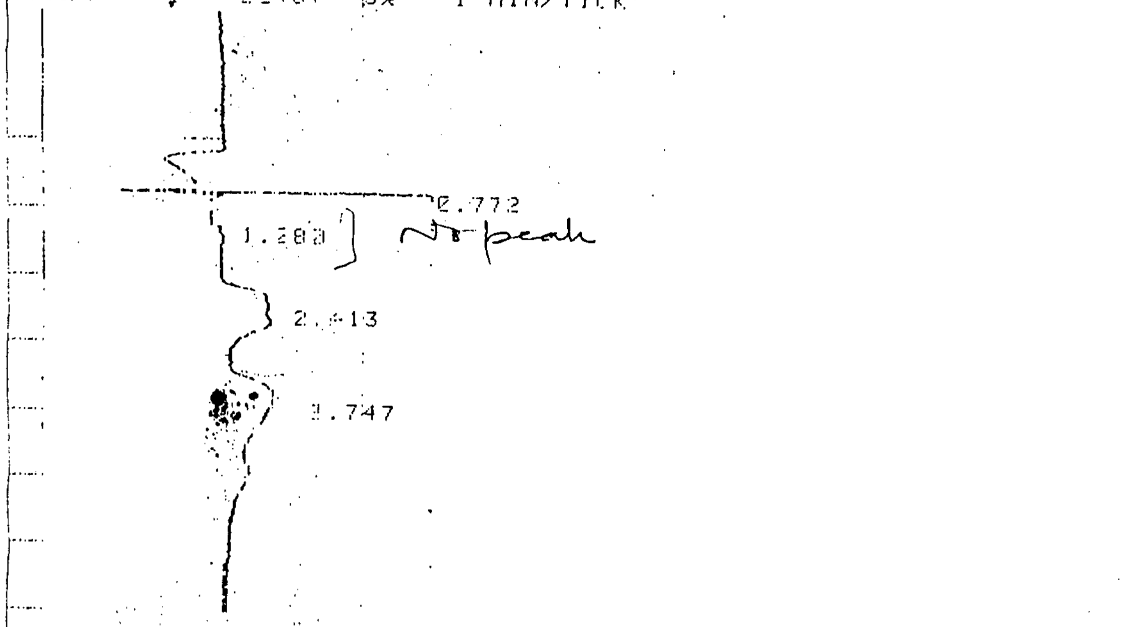
MULTIPLIER: 1.00000

MSD | 10 ml.

10 ml. of sample

PVC
CABLE UNIT,
VISHWASNAGAR

CHART SPEED: 1.0 CM/MIN
ATTEN: 1 ZERO: 5% 1 MIN/TICK



TITLE: VCM CONTENT

4:29 0 JAN 79

CHANNEL NO: 1 SAMPLE:

METHOD: ASD

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	HEIGHT COUNTS	SEP CODE
		100.0000	0.772	260	BV
TOTALS:		100.0000		260	

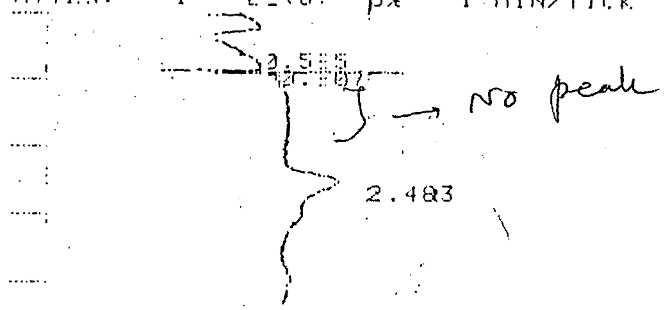
MULTIPLIER: 1.00000

MSD/Works

100 ml of sample

PVC CABLE UNIT, VISHWASNAGAR

CHART SPEED 1.0 CM/MIN
ATTEN: 1 ZERO: 5% 1 MIN/TICK



TITLE: VCM CONTENT

6:06 0 JAN 79

CHANNEL NO: 1 SAMPLE:

METHOD: ASD

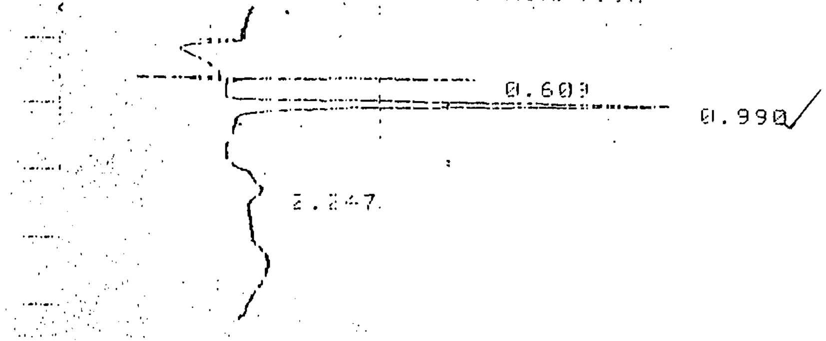
PEAK NO	PEAK NAME	RESULT	TIME (MIN)	HEIGHT COUNTS	SEP CODE
		100.0000	0.367	185	VV
TOTALS:		100.0000		185	

MULTIPLIER: 1.00000

VCM std: 3.6 mg

PVC
CABLE UNIT,
VISHWASNAGAR

CHART SPEED 1.0 CM/MIN
ATTEN: 1 ZERO: 5% 1 MIN/TICK



TITLE: VCM CONTENT 0:37 0 JAN 79

CHANNEL NO: 1 SAMPLE: METHOD: ASD

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	HEIGHT COUNTS	SEP CODE
		43.6747	0.609	290	BV
2		56.3253	0.990	374	BB
TOTALS:		100.0000		664	

MULTIPLIER: 1.00000

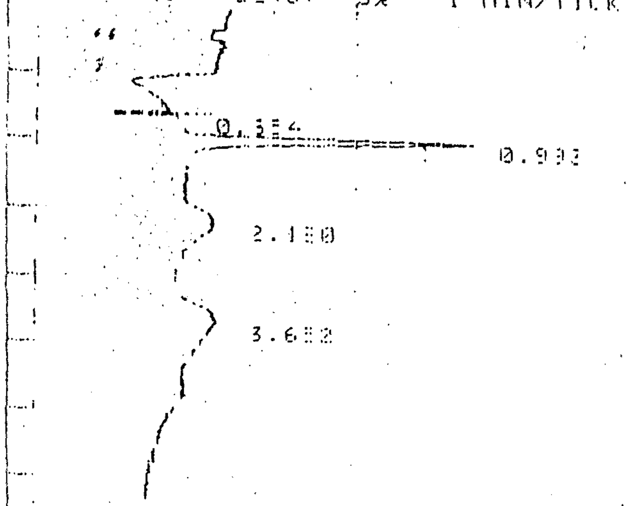
PVC

VCM std : 2.4 ug

PVC
CABLE UNIT,
VISHWASNAGA

1.2 ug
2.4 ug
3.6 ug

-IFT SPEED: 1.0 CM/MIN
TTEN: 1 ZERO: 5% 1 MIN/TICK



FILE: VCM CONTENT

1:49 0 JAN 79

-NNEL NO: 1 SAMPLE:

METHOD: ASD

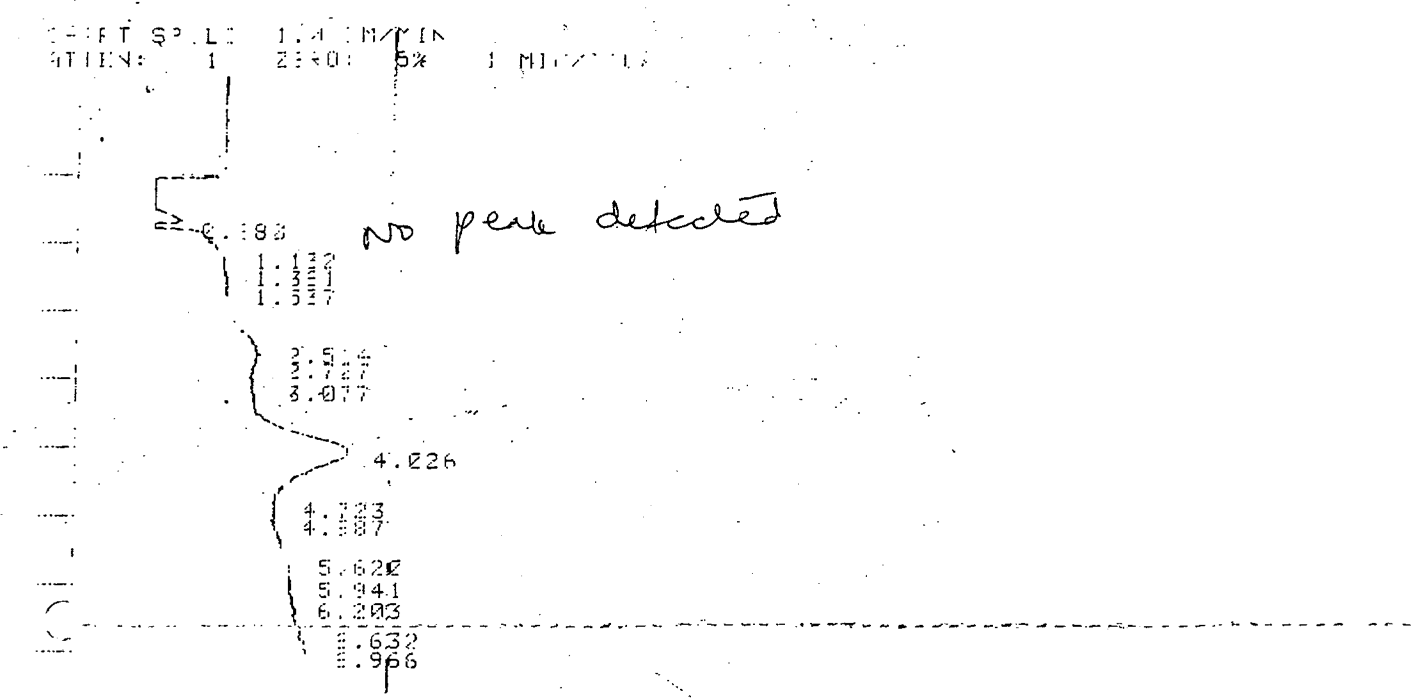
E-I N-	PEAK NAME	RESULT	TIME (MIN)	HEIGHT COUNTS	SEP CODE
		100.0000	0.993	242	BB
TALS:		100.0000		242	

-TIPLIER: 1.00000

PVC - TAPES AND
DUMMY CORES,
KIRTINAGAR

10 ml

10 ml ~~injection~~ of the sample.



TITLE: VCM CONTENT 4:3[illegible] [illegible] 79

CHANNEL NO: 1 SAMPLE:

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	[illegible] CORR

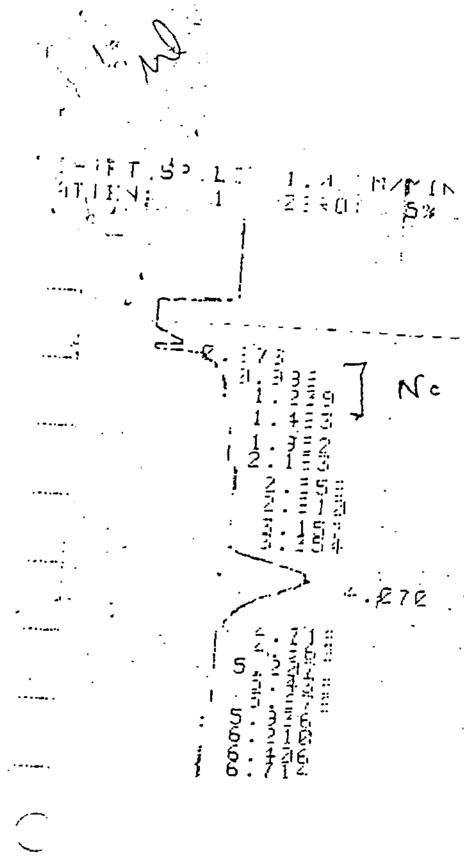
TOTALS: 0.000[illegible]

MULTIPLIER: 1.[illegible]

ERRORS:
NO PEAKS

PVC
TAPES AND DUMMY
CORES,
KIRTINAGAR

1 ml injection of the sample



No peak detected

TITLE: VCM CONTENT

CHANNEL NO: 1   SAMPLE: 4:29   79

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	AREA COUNTS
TOTALS:		0.0000		0

MULTIPLIER: 1.00000

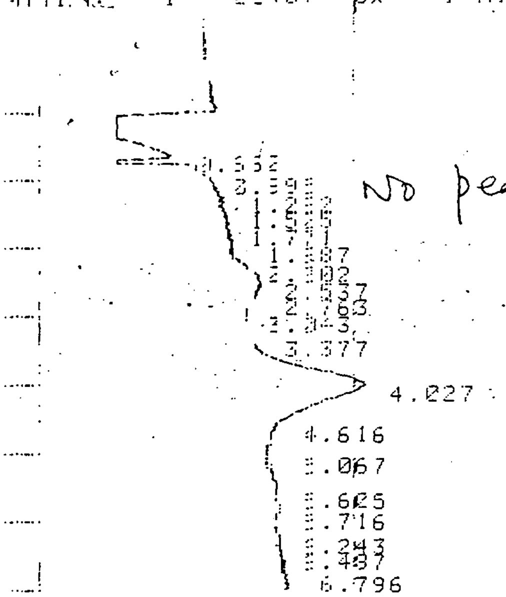
ERRORS:
NO PEAKS

PVC TAPES
AND DUMMY CORES
KIRTINAGAR

100 ml

100 ml injection of the sample.

CHART SPEED 1.4 M/MIN
ATTEN 1 ZERO: 5% 1 MIN/TICK



TITLE: VCM CONTENT 4:5[illegible] JUL 79

CHANNEL NO: 1 SAMPLE: [illegible]

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	HEIGHT COUNTS	[illegible]
TOTALS:		0.0000		0	

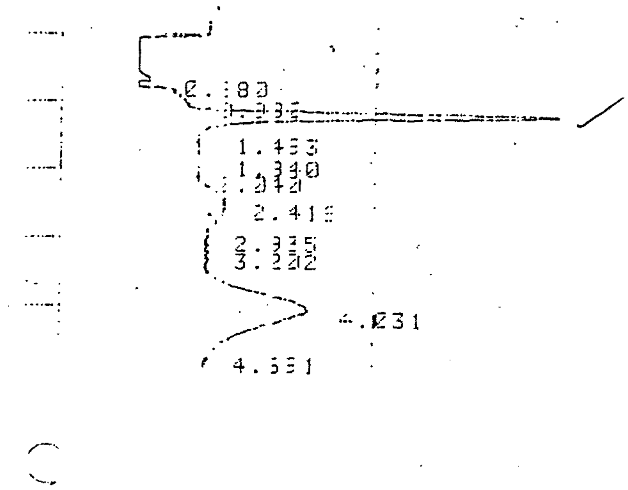
MULTIPLIER: 1.00000

ERRORS:
NO PEAKS

PVC TAPES
AND DUMMY CORES,
KIRTINAGAR

Std VCM(3) :- 3.9mg

CHART SPEED 1.0 CM/MIN
ATTEN: 1 ZERO: 5% 1 MIN/TICK



TITLE: VCM CONTENT 2:46 0 JAN 79

CHANNEL NO: 1 SAMPLE: METHOD:

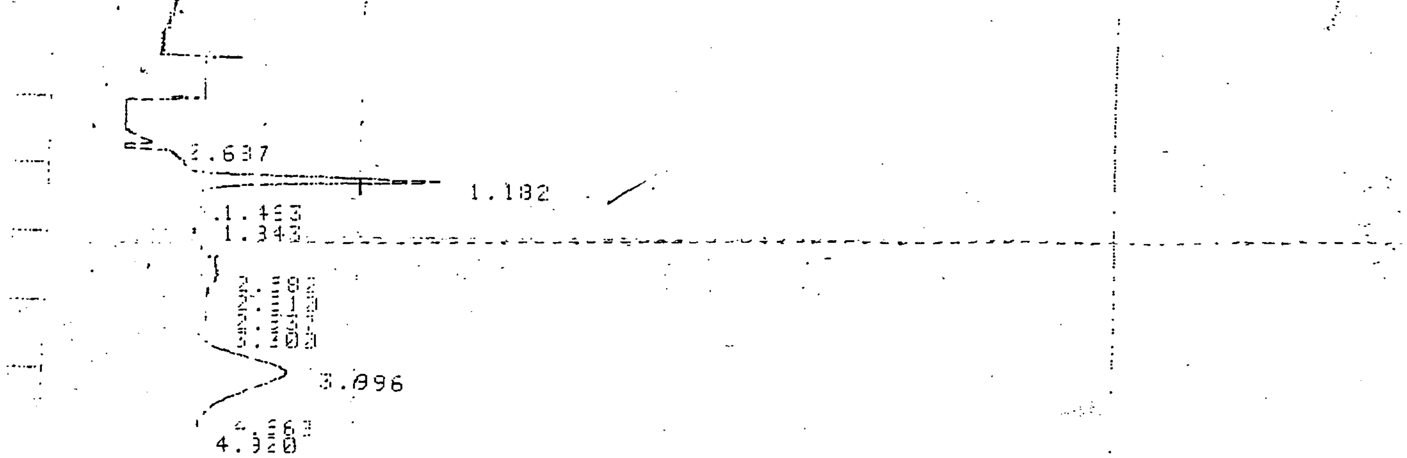
PEAK NO	PEAK NAME	RESULT	TIME (MIN)	HEIGHT COUNTS	SEP CODE
		100.0000	1.18	469	VV
TOTALS:		100.0000		469	

MULTIPLIER: 1.00000

PVC TAPES
AND DUMMY CORES,
KIRTINAGAR

Std VCM 2 : 26 mg

CHART SPEED: 1.0 CM/MIN
ATTEN: 1 ZERO: 6% 1 MIN/TICK



TITLE: VCM CONTENT 2:40 0 JAN 79

CHANNEL NO: 1 SAMPLE: METHOD: AND

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	HEIGHT COUNTS	SEP CODE
		100.0000	1.182	371	VV
TOTALS:		100.0000		371	

MULTIPLIER: 1.000000