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IN THIS ISSUE

EDITORIAL

Invention of plastic and its usage in all walks of life including packaging materials, disposable bags, and disposable syringes has made it indispensible. It has replaced the traditional packing material viz. paper and cloth etc. The plastic carry bags are very convenient as well as cheap. In India there is substantial growth in plastics production and usage in the recent years. Due to increased use of plastic products there is also an increase in the generation of plastic waste. The non biodegradable plastic waste is considered as environmental hazard and the quantum of waste has grown in recent times due to the "use and throw culture" of modern civilization. Estimated quantity of plastic waste generation in India is: 10,000 tonnes per day. It accounts for around 9% of Municipal Solid Waste. Per capita generation of Plastic Waste is around: 5.7 kg /annum. It is interesting to note that in India 60% of plastic waste is recycled. There are various hazards posed by plastic waste:-

a. Discarded bags find their way into the city drainage system, resulting in blockage and unhygienic environmental condition leading to health hazard.
b. Littering of land also reduces rate of rain water percolation, resulting in further lowering of already low groundwater levels in our cities.
c. There are cases of death of stray animals due to consumption of plastic bags along with the food.

Recently, the safety of Bisphenol A, a chemical present in many plastic water bottles, food containers, and the lining of many tin cans, has drawn attention. Bisphenol A (BPA) is a suspected endocrine disruptor and little is known about its distribution and transport in the environment. Open burning of plastic waste is very dangerous for human as well as environmental health. PVC (polyvinylchloride) is a common constituent of plastic products such as: bottles, jugs, bags and packaging materials. When these plastics are burnt, carbon monoxide, dioxins and furans are released into the atmosphere. Dioxins and furans have also been linked to cancer and respiratory diseases. Scientific approaches are needed to manage the problem of plastic waste. The 3R approach of Reduce, Reuse and Recycle can make a substantial difference in the management of this problem. It should start with Identification of local needs matched with local resources; adoption of state of- the-art technology and implementation of regulation. Instead of banning plastic across the country, efforts must be made to ensure that an effective and concerted plastic waste management (PWM) mechanism is implemented so that plastics do not become the cause of concern.

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ODDS AND ENDS

Degradation of plastic carrier bags in the marine environment.

There is considerable concern about the hazards that plastic debris presents to wildlife. Use of polymers that degrade more quickly than conventional plastics presents a possible solution to this problem. Here we investigate breakdown of two oxo-biodegradable plastics, compostable plastic and standard polyethylene in the marine environment. Tensile strength of all materials decreased during exposure, but at different rates. Compostable plastic disappeared from our test rig between 16 and 24weeks whereas approximately 98% of the other plastics remained after 40weeks. Some plastics require UV light to degrade. Transmittance of UV through oxo-biodegradable and standard polyethylene decreased as a consequence of fouling such that these materials received 90% less UV light after 40weeks. Our data indicate that compostable plastics may degrade relatively quickly compared to oxo-biodegradable and conventional plastics. While degradable polymers offer waste management solutions, there are limitations to their effectiveness in reducing hazards associated with plastic debris.

Mar Pollut Bull. 2010 Oct 18.
doi:10.1016/j.marpolbul.2010.08.005

Stress-strain response of plastic waste mixed soil.

Recycling plastic waste from water bottles has become one of the major challenges worldwide. The present study provides an approach for the use plastic waste as reinforcement material in soil. The experimental results in the form of stress-strain-pore water pressure response are presented. Based on experimental test results, it is observed that the strength of soil is improved and compressibility reduced significantly with addition of a small percentage of plastic waste to the soil. The use of the improvement in strength and compressibility response due to inclusion of plastic waste can be advantageously used in bearing capacity improvement and settlement reduction in the design of shallow foundations.

Waste Manag. 2010 Oct 13.
doi:10.1016/j.wasman.2010.09.018

Chemical synthesis of fully biomass-based poly(butylene succinate) from inedible-biomass-based furfural and evaluation of its biomass carbon ratio.

We have produced fully biomass-based poly(butylene succinate) (PBS) from furfural produced from inedible agricultural cellulosic waste. Furfural was oxidized to give fumaric acid. Fumaric acid was hydrogenated under high pressure with a palladium rhenium/carbon catalyst to give 1,4 butanediol, and with a palladium/carbon catalyst to give succinic acid. Dimethyl succinate was synthesized from fumaric acid by esterification and hydrogenation under normal pressure. Fully biomass-based PBS was obtained by polycondensation of biomass-based 1,4-butanediol and biomass-based succinic acid or dimethyl succinate. The biomass carbon ratio calculated from (14)C concentrations measured by accelerator mass spectroscopy (AMS) verified that the PBS obtained in this study contained only biomass carbon. The polycondensation of biomass-based 1,4-butanediol and petroleum-based terephthalic acid or dimethyl terephthalate gave partially biomass-based poly(butylene terephthalate), which is an engineering plastic.

Biomacromolecules. 2010 Oct 11;11(10):2760-5.

Impact of plastics on fate and transport of organic contaminants in landfills.

Factors controlling organic contaminant sorption to common plastics in municipal solid waste were identified. Consumer plastics [drinking water container, prescription drug bottle, soda bottle, disposable cold cup, computer casing, furniture foam, carpet, vinyl flooring, formica sheet] and model polymers [high-density polyethylene (HDPE), medium-density polyethylene, low-density polyethylene, poly(vinyl chloride) (PVC)] were characterized by X-ray diffractometry, differential scanning calorimetry, and elemental analysis. The material characterization was used to interpret batch isotherm and kinetic data. Kp values describing toluene sorption to rubbery or "soft" polymers could be normalized by the amorphous polymer fraction ($f_{(amorphous)}$) but not by the organic carbon fraction ($f_{(oc)}$). Diffusion coefficients (D) describing the uptake rate of toluene by rubbery plastics (HDPE, drinking water container, prescription drug bottle) were similar (D approximately $10^{(-10)}$ cm^2/s), indicating that pure HDPE can be used as a model for rubbery plastics. Toluene diffusivity was similar among glassy or "hard" plastics (PVC, soda bottle, computer casing, disposable cold cup; D approximately $10^{(-12)}$ cm^2/s) but lower than for rubbery plastics. Plastics in landfills are potential sinks of hydrophobic organic contaminants (HOCs) because of their higher affinity for HOCs compared to lignocellulosic materials and the slow desorption of HOCs from glassy plastics.

Environ Sci Technol. 2010 Aug 15;44(16):6396-402.

Ubiquity of bisphenol A in the atmosphere.

Bisphenol A (BPA) is a suspected endocrine disruptor in the environment. However, little is known about its distribution and transport in the atmosphere. Here, the concentrations of BPA in the atmospheric aerosols from urban, rural, marine, and the polar regions were measured using solvent extraction/derivatization and gas chromatography/mass spectrometry technique. The concentrations of BPA (1-17,400 pg $m^{(-3)}$) ranged over 4 orders of magnitude in the world with a declining trend from the continent (except for the Antarctica) to remote sites. A positive correlation was found between BPA and 1,3,5-triphenylbenzene, a tracer for plastic burning, in urban regions, indicating that the open burning of plastics in domestic waste should be a significant emission source of atmospheric BPA. Our results suggest that the ubiquity of BPA in the atmosphere may raise a requirement for the evaluation of health effects of BPA in order to control its emission sources, for example, from plastic burning.

Environ Pollut. 2010 Oct;158(10):3138-43.

Reutilization of thermostable polyester wastes by means of agglomeration with phenolic resins.

We report on the possibility of obtaining organic polymeric matrixes allowing the development of new high performance fire-resistant products by recycling downsized thermostable waste materials. Phenolic resins have been used as binders for recycled waste. Furthermore, considering that reinforced plastic triturations have superior properties (chemical, mechanical, water resistance, etc.) to wood agglomerates, significant advantages over conventional materials are anticipated. In summary, we propose a viable solution to some of the known problems caused by the consumption of wood and to the needs of strengthened plastic processing engineering. Using resins as a binder, several fire-resistant prototypes were prepared from polyester waste, and their mechanical properties, thermal stability, and fire-resistant properties were analyzed.

Waste Manag. 2010 Nov;30(11):2305-11.

Are marine plastic particles transport vectors for organic pollutants to the Arctic?

Plastic litter accounts for 50-80% of waste items stranded on beaches, floating on the ocean surface and lodged in the seabed. Organic pollutants can be absorbed onto plastic particles from sea water, attached to their surfaces or included in the plastic matrix as additives. Such chemicals may be transported to remote regions by buoyant plastics and ocean currents. We have estimated mass fluxes of polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), and perfluorooctanoic acid (PFOA) to the Arctic via the main ocean currents and compared them to those in the dissolved state and in air. Substance fluxes with atmospheric or sea water currents account for several tons per year, whereas those mediated by plastics are four to six orders of magnitude smaller. However, the significance of various pollutant transport routes does not depend only on absolute mass fluxes but also on bioaccumulation in marine food chains.

Mar Pollut Bull. 2010 Oct;60(10):1810-4.

Upcycling: converting waste plastics into paramagnetic, conducting, solid, pure carbon microspheres.

The recent tremendous increase in the volume of waste plastics (WP) will have a harmful environmental impact on the health of living beings. Hundreds of years are required to degrade WP in atmospheric conditions. Hence, in coming years, in addition to traditional recycling services, innovative "upcycling" processes are necessary. This article presents an environmentally benign, solvent-free autogenic process that converts various WP [low density polyethylene (LDPE), high density polyethylene (HDPE), polyethylene terephthalate (PET), polystyrene (PS), or their mixtures] into carbon microspheres (CMSs), an industrially significant, value-added product. The thermal dissociation of these individual or mixed WP in a closed reactor under autogenic pressure (approximately 1000 psi) produced dry, pure powder of CMSs. In this paper, the optimization of process parameters such as the effect of mixing of WP with other materials, and the role of reaction temperature and time are reported. Employing advanced analytical techniques, the atomic structure, composition, and morphology of as-obtained CMSs were analyzed. The room-temperature paramagnetism in CMSs prepared from waste LDPE, HDPE, and PS was further studied by electron paramagnetic resonance (EPR). The conducting and paramagnetic nature of CMSs holds promise for their potential applications in toners, printers, paints, batteries, lubricants, and tires.

Environ Sci Technol. 2010 Jun 15;44(12):4753-9.

Spatial patterns of plastic debris along Estuarine shorelines.

The human population generates vast quantities of waste material. Macro (>1 mm) and microscopic (<1 mm) fragments of plastic debris represent a substantial contamination problem. Here, we test hypotheses about the influence of wind and depositional regime on spatial patterns of micro- and macro-plastic debris within the Tamar Estuary, UK. Debris was identified to the type of polymer using Fourier-transform infrared spectroscopy (FT-IR) and categorized according to density. In terms of abundance, microplastic accounted for 65% of debris recorded and mainly comprised polyvinylchloride, polyester, and polyamide. Generally, there were greater quantities of plastic at downwind sites. For macroplastic, there were clear patterns of distribution for less dense items, while for microplastic debris, clear patterns were for denser material. Small particles of sediment and plastic are both likely to settle slowly from the water-column and are likely to be transported by the flow of water and be deposited in areas where the movements of water are slower. There was, however, no relationship between the abundance of microplastic and the proportion of clay in sediments from the strandline. These results illustrate how FT-IR spectroscopy can be used to identify the different types of plastic and in this case was used to indicate spatial patterns, demonstrating habitats that are downwind acting as potential sinks for the accumulation of debris.

Environ Sci Technol. 2010 May 1;44(9):3404-9.

Low temperature conversion of plastic waste into light hydrocarbons.

Advance recycling through pyrolytic technology has the potential of being applied to the management of plastic waste (PW). For this purpose 1 l volume, energy efficient batch reactor was manufactured locally and tested for pyrolysis of waste plastic. The feedstock for reactor was 50 g waste polyethylene. The average yield of the pyrolytic oil, wax, pyrogas and char from pyrolysis of PW were 48.6, 40.7, 10.1 and 0.6%, respectively, at 275 ^{0} C with non-catalytic process. Using catalyst the average yields of pyrolytic oil, pyrogas, wax and residue (char) of 50 g of PW was 47.98, 35.43, 16.09 and 0.50%, respectively, at operating temperature of 250 ^{0} C. The designed reactor could work at low temperature in the absence of a catalyst to obtain similar products as for a catalytic process.

J Hazard Mater. 2010 Jul 15;179(1-3):15-20.

Remediating plastic waste into carbon nanotubes.

Polyethylene-based used plastics needs hundreds of years to degrade in atmospheric conditions. Thus, in addition to conventional recycling facilities for polymer waste (PW), innovative solutions are required. This paper describes a solvent-free process that converts PW such as low-density (LD) and high-density polyethylene (HDPE) into multi-walled carbon nanotubes (MWCNTs) via thermal dissociation in the presence of chemical catalysts in a closed system under autogenic pressure. Specifically, the optimization of process parameters, e.g. selection and amounts of catalysts, density effects of PE, autogenic pressure measurements, and a reaction mechanism for the growth of MWCNTs is explained. The composition, morphology, and atomic structure of the as-obtained MWCNTs are characterized employing advanced structural, spectroscopic, and imaging techniques. We have measured the unique magnetic and electrical conductivity behaviours of as-prepared MWCNTs to assess their potential applications as advanced materials. This reproducible process presents an opportunity to use PW as a feedstock for the production of MWCNTs, industrially significant value-added products. Among the known methods for the fabrication of MWCNTs, the present controlled dissociation of PW is one of the inexpensive and straightforward methods.

J Environ Monit. 2010 Feb;12_2:455-9.

Physico-chemical pre-treatment and biotransformation of wastewater and wastewater sludge--fate of bisphenol A.

Bisphenol A (BPA), an endocrine disrupting compound largely used in plastic and paper industry, ends up in aquatic systems via wastewater treatment plants (WWTPs) among other sources. The identification and quantification of BPA in wastewater (WW) and wastewater sludge (WWS) is of major interest to assess the endocrine activity of treated effluent discharged into the environment. Many treatment technologies, including various pre-treatment methods, such as hydrolysis, Fenton oxidation, peroxidation, ultrasonication and ozonation have been developed in order to degrade BPA in WW and WWS and for the production of WWS based value-added products (VAPs). WWS based VAPs, such as biopesticides, bioherbicides, biofertilizers, bioplastics and enzymes are low cost biological alternatives that can compete with chemicals or other cost intensive biological products in the current markets. However, this field application is disputable due to the presence of these organic compounds which has been discussed with a perspective of simultaneous degradation. The pre-treatment produces an impact on rheology as well as value-addition which has been reviewed in this paper. Various analytical techniques available for the detection of BPA in WW and WWS are also discussed. Presence of heavy metals and possible thermodynamical behavior of the compound in WW and WWS can have major impact on BPA removal, which is also included in the review.

Chemosphere. 2010 Feb;78(8):923-41.

Addition of tracers into the polypropylene in view of automatic sorting of plastic wastes using X-ray fluorescence spectrometry.

This study focused on the detection of rare earth oxides, used as tracers for the identification of polymer materials, using XRF (X-ray fluorescence) spectrometry. The tests were carried out in a test system device which allows the collection of static measurements of the samples' spectrum through the use of energy dispersive X-ray fluorescence technology. A sorting process based on tracers added into the polymer matrix is proposed in order to increase sorting selectivity of polypropylene during end-of-life recycling. Tracers consist of systems formed by one or by several substances dispersed into a material, to add a selective property to it, with the aim of improving the efficiency of sorting and high speed identification. Several samples containing rare earth oxides (Y_2O_3, CeO_2, Nd_2O_3, Gd_2O_3, Dy_2O_3, Er_2O_3 and Yb_2O_3) in different concentrations were prepared in order to analyse some of the parameters which can influence the detection, such as the concentration of tracers, the acquisition time and the possible overlapping among the tracers. This work shows that by using the XRF test system device, it was possible to detect 5 of the 7 tracers tested for 1min exposure time and at a concentration level of 1000ppm. These two parameters will play an important role in the development of an industrial device, which indicates the necessity of further works that needs to be conducted in order to reduce them.

Waste Manag. 2010 Apr;30(4):591-6.

Pyrolysis of municipal plastic wastes: Influence of raw material composition.

The objective of this work is the study of pyrolysis as a feedstock recycling process, for valorizing the rejected streams that come from industrial plants, where packing and packaging wastes are classified and separated for their subsequent mechanical recycling. Four real samples collected from an industrial plant at four different times of the year, have been pyrolysed under nitrogen in a $3.5dm^{(3)}$ autoclave at $500^{0}C$ for 30min. Pyrolysis liquids are a complex mixture of organic compounds containing valuable chemicals as styrene, ethyl-benzene, toluene, etc. Pyrolysis solids are composed of the inorganic material contained in the raw materials, as well as of some char formed in the pyrolysis process, and pyrolysis gases are mainly composed of hydrocarbons together with some CO and CO_2, and have very high gross calorific values (GCV). It has been proved by the authors that the composition of the raw material (paper, film, and metals contents) plays a significant role in the characteristics of pyrolysis products. High paper content yields water in the pyrolysis liquids, and CO and CO_2 in the gases, high PE film content gives rise to high viscosity liquids, and high metals content yields more aromatics in the liquid products, which may be attributed to the metals catalytic effect.

Waste Manag. 2010 Apr;30(4):620-7.

Biodegradation of low-density polyethylene (LDPE) by isolated fungi in solid waste medium.

In this study, biodegradation of low-density polyethylene (LDPE) by isolated landfill-source fungi was evaluated in a controlled solid waste medium. The fungi, including *Aspergillus fumigatus, Aspergillus terreus* and *Fusarium solani,* were isolated from samples taken from an aerobic aged municipal landfill in Tehran. These fungi could degrade LDPE via the formation of a biofilm in a submerged medium. In the sterilized solid waste medium, LPDE films were buried for 100 days in a 1-L flask containing 400 g sterile solid waste raw materials at $28^{0}C$. Each fungus was added to a separate flask. The moisture content and pH of the media were maintained at the optimal levels for each fungus. Photo-oxidation (25 days under UV-irradiation) was used as a pretreatment of the LDPE samples. The progress of the process was monitored by measurement of total organic carbon (TOC), pH, temperature and moisture. The results obtained from monitoring the process using isolated fungi under sterile conditions indicate that these fungi are able to grow in solid waste medium. The results of FT-IR and SEM analyses show that *A. terreus* and *A. fumigatus*, despite the availability of other organic carbon of materials, could utilize LDPE as carbon source. While there has been much research in the field of LDPE biodegradation under solid conditions, this is the first report of degradation of LDPE by *A. fumigatus*.

Waste Manag. 2010 Mar;30(3):396-401.

Recovery of plastic wastes from dumpsite as refuse-derived fuel and its utilization in small gasification system.

An effort to utilize solid wastes at

dumpsite as refuse-derived fuel (RDF) was carried out. The produced RDF briquette was then utilized in the gasification system. These wastes were initially examined for their physical composition and chemical characteristics. The wastes contained high plastic content of 24.6-44.8%, majority in polyethylene plastic bag form. The plastic wastes were purified by separating them from other components through manual separation and trommel screen after which their content increased to 82.9-89.7%. Subsequently, they were mixed with binding agent (cassava root) and transformed into RDF briquette. Maximum plastic content in RDF briquette was limit to 55% to maintain physical strength and maximum chlorine content. The RDF briquette was tested in a down-draft gasifier. The produced gas contained average energy content of 1.76 MJ/m(3), yielding cold gas efficiency of 66%. The energy production cost from this RDF process was estimated as USD0.05 perkWh.

Bioresour Technol. 2010 Mar;101(5):1522-7.

Recycling of plastic: accounting of greenhouse gases and global warming contributions.

Major greenhouse gas (GHG) emissions related to plastic waste recycling were evaluated with respect to three management alternatives: recycling of clean, single-type plastic, recycling of mixed/contaminated plastic, and use of plastic waste as fuel in industrial processes. Source-separated plastic waste was received at a material recovery facility (MRF) and processed for granulation and subsequent downstream use. In the three alternatives, plastic was assumed to be substituting virgin plastic in new products, wood in low-strength products (outdoor furniture, fences, etc.), and coal or fuel oil in the case of energy utilization. GHG accounting was organized in terms of indirect upstream emissions (e.g. provision of energy, fuels, and materials), direct emissions at the MRF (e.g. fuel combustion), and indirect downstream emissions (e.g. avoided emissions from production of virgin plastic, wood, or coal/oil). Combined, upstream and direct emissions were estimated to be roughly between 5 and 600 kg CO_2-eq. tonne(-1) of plastic waste depending on treatment at the MRF and CO_2 emissions from electricity production. Potential downstream savings arising from substitution of virgin plastic, wood, and energy fuels were estimated to be around 60-1600 kg CO_2-eq. Tonne of plastic waste depending on substitution ratios and CO_2 emissions from electricity production. Based on the reviewed data, it was concluded that substitution of virgin plastic should be preferred. If this is not viable due to a mixture of different plastic types and/or contamination, the plastic should be used for energy utilization. Recycling of plastic waste for substitution of other materials such as wood provided no savings with respect to global warming.

Waste Manag Res. 2009 Nov;27(8):763-72.

The synthesis of nanostructured SiC from waste plastics and silicon powder.

Waste plastics constitute a growing environmental problem. Therefore, the treatment of waste plastics should be considered. Here we synthesize 3C-SiC nanomaterials coexisting with amorphous graphite particles utilizing waste plastics and Si powder at 350-500^{0}C in a stainless steel autoclave. 3C-SiC could be finally obtained after refluxing with aqueous $HClO_4$ (70 wt%) at 180^{0}C. X-ray powder diffraction patterns indicate that the product is 3C-SiC with the calculated lattice constant a = 4.36 A. Transmission electron microscopy (TEM) images show that the SiC samples presented two morphologies: hexagonal platelets prepared by the waste detergent bottles or beverage bottles and nanowires prepared by waste plastic bags respectively. The corresponding selected area electron diffraction (SAED) pattern indicates that either the entire hexagonal platelet or the nanowire is single crystalline. High-resolution TEM shows the planar surfaces of the SiC platelet correspond to {111}planes; the lateral surfaces are {110} planes and the preferential growth direction of the nanowires is along [111]. The output of SiC was approximately 39% based on the amount of Si powder.

Nanotechnology. 2009 Sep 2;20(35):355604.

Recycling and recovery routes of plastic solid waste (PSW): a review.

Plastic solid waste (PSW) presents challenges and opportunities to societies regardless of their sustainability awareness and technological advances. In this paper, recent progress in the recycling and recovery of PSW is reviewed. A special emphasis is paid on waste generated from polyolefinic sources, which makes up a great percentage of our daily single-life cycle plastic products. The four routes of PSW treatment are detailed and discussed covering primary (re-extrusion), secondary (mechanical), tertiary (chemical) and quaternary (energy recovery) schemes and technologies. Primary recycling, which involves the re-introduction of clean scrap of single polymer to the extrusion cycle in order to produce products of the similar material, is commonly applied in the processing line itself but rarely applied among recyclers, as recycling materials rarely possess the required quality. The various waste products, consisting of either end-of-life or production (scrap) waste, are the feedstock of secondary techniques, thereby generally reduced in size to a more desirable shape and form, such as pellets, flakes or powders, depending on the source, shape and usability. Tertiary treatment schemes have contributed greatly to the recycling status of PSW in recent years. Advanced thermo-chemical treatment methods cover a wide range of technologies and produce either fuels or petrochemical feedstock. Nowadays, non-catalytic thermal cracking (thermolysis) is receiving renewed attention, due to the fact of added value on a crude oil barrel and its very valuable yielded products. But a fact remains that advanced thermo-chemical recycling of PSW (namely polyolefins) still lacks the proper design and kinetic background to target certain desired products and/or chemicals. Energy recovery was found to be an attainable solution to PSW in general and municipal solid waste (MSW) in particular. The amount of energy produced in kilns and reactors applied in this route is sufficiently investigated up to the point of operation, but not in terms of integration with either petrochemical or converting plants. Although primary and secondary recycling schemes are well established and widely applied, it is concluded that many of the PSW tertiary and quaternary treatment schemes appear to be robust and worthy of additional investigation.

Waste Manag. 2009 Oct;29(10):2625-43.

Plastics, the environment and human health: current consensus and future trends.

Plastics have transformed everyday life; usage is increasing and annual production is likely to exceed 300 million tonnes by 2010. In this concluding paper to the Theme Issue on Plastics, the Environment and Human Health, we synthesize current understanding of the benefits and concerns surrounding the use of plastics and look to future priorities, challenges and opportunities. It is evident that plastics bring many societal benefits and offer future technological and medical advances. However, concerns about usage and disposal are diverse and include accumulation of waste in landfills and in natural habitats, physical problems for wildlife resulting from ingestion or entanglement in plastic, the leaching of chemicals from plastic products and the potential for plastics to transfer chemicals to wildlife and humans. However, perhaps the most important overriding concern, which is implicit throughout this volume, is that our current usage is not sustainable. Around 4 per cent of world oil production is used as a feedstock to make plastics and a similar amount is used as energy in the process. Yet over a third of current production is used to make items of packaging, which are then rapidly discarded. Given our declining reserves of fossil fuels, and finite capacity for disposal of waste to landfill, this linear use of hydrocarbons, via packaging and other short-lived applications of plastic, is simply not sustainable. There are solutions, including material reduction, design for end-of-life recyclability, increased recycling capacity, development of bio-based feedstocks, strategies to reduce littering, the application of green chemistry life-cycle analyses and revised risk assessment approaches. Such measures will be most effective through the combined actions of the public, industry, scientists and policymakers. There is some urgency, as the quantity of plastics produced in the first 10 years of the current century is likely to approach the quantity produced in the entire century that preceded.

Philos Trans R Soc Lond B Biol Sci. 2009 Jul 27;364(1526):2153-66.

Structuring policy problems for plastics, the environment and human health: reflections from the UK.

How can we strengthen the science-policy interface for plastics, the environment and human health? In a complex policy area with multiple stakeholders, it is important to clarify the nature of the particular plastics-related issue before trying to understand how to reconcile the supply and demand for evidence in policy. This article proposes a simple problem typology to assess the fundamental characteristics of a policy issue and thus identify appropriate processes for science-policy interactions. This is illustrated with two case studies from one UK Government Department, showing how policy and science meet over the environmental problems of plastics waste in the marine environment and on land. A problem-structuring methodology helps us understand why some policy issues can be addressed through relatively linear flows of science from experts to policymakers but why others demand a more reflexive approach to brokering the knowledge between science and policy. Suggestions are given at the end of the article for practical actions that can be taken on both sides.

Philos Trans R Soc Lond B Biol Sci. 2009 Jul 27;364(1526):2141-51.

Biodegradable and compostable alternatives to conventional plastics.

Packaging waste forms a significant part of municipal solid waste and has caused increasing environmental concerns, resulting in a strengthening of various regulations aimed at reducing the amounts generated. Among other materials, a wide range of oil-based polymers is currently used in packaging applications. These are virtually all non-biodegradable, and some are difficult to recycle or reuse due to being complex composites having varying levels of contamination. Recently, significant progress has been made in the development of biodegradable plastics, largely from renewable natural resources, to produce biodegradable materials with similar functionality to that of oil-based polymers. The expansion in these bio-based materials has several potential benefits for greenhouse gas balances and other environmental impacts over whole life cycles and in the use of renewable, rather than finite resources. It is intended that use of biodegradable materials will contribute to sustainability and reduction in the environmental impact associated with disposal of oil-based polymers. The diversity of biodegradable materials and their varying properties makes it difficult to make simple, generic assessments such as biodegradable products are all 'good' or petrochemical-based products are all 'bad'. This paper discusses the potential impacts of biodegradable packaging materials and their waste management, particularly via composting. It presents the key issues that inform judgements of the benefits these materials have in relation to conventional, petrochemical-based counterparts. Specific examples are given from new research on biodegradability in simulated 'home' composting systems. It is the view of the authors that biodegradable packaging materials are most suitable for single-use disposable applications where the post-consumer waste can be locally composted.

Philos Trans R Soc Lond B Biol Sci. 2009 Jul 27;364(1526):2127-39.

Plastic Waste and its Management Strategies

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Introduction

Plastics are everywhere in today's world. They have wide applications including packaging and storage items, transportation, household goods, cables, flooring, baby feeding bottles, laminates, biomedical devices, health care products, agriculture, buildings, innovative products etc. The usage of polymeric products is growing at a faster pace throughout the globe. Innovations in packaging are a continual process for increasing processing efficiency and improving food safety as per the regulatory requirements. Plastics though safe, its indiscriminate application of the plastic products in the various sectors has lead to the vast amount of hazardous plastic waste generation. Growing public concern about environmental pollution caused by accumulation of non-destructible solid waste has stimulated the development of proper waste management practices. The quantum of solid waste is ever increasing due to the rapid increase in population, uncontrolled developmental activities, changes in life style, and socio-economic conditions. Plastics waste constitutes a significant portion of the total municipal solid waste (MSW) generated.

Nature of the Plastic Waste

The plastic waste can be categorized

into thermoplasts and thermosets plastics The thermoplastics, constitutes the major portion (nearly 80%) while the thermosetting plastic waste constitutes only 20% of total plastics waste generated. The commonly used plastics including Polyethylene Terephthalate (PET), Poly Ethylene, Poly Vinyl Chloride (PVC), Polypropylene (PP), Polystyrene (PS) etc. are the recyclable thermoplastics. However, the thermosetting plastics include epoxy resins, polyester, melamine formaldehyde, phenolic formaldehyde, silicones, urea formaldehyde, polyurethane, etc.

Plastic Waste: Environmental & Health Implications

The most common problem faced due to the plastics waste is the choking of the drains making the local environment unhygienic by providing a breeding place for the mosquitoes and promoting the growth of other pathogenic forms. Also the local method adopted to

Common Contaminants	Health effects
Vinyl Chloride	Angiosarcoma of Liver
Acrylamide	Neurotoxic
Styrene	Raynaud's phenomenon
UV Absorbers	Carcinogenic
Dioxin	Hepatotoxic, carcinogenic
Phthalates	Endocrine Disruptors

clear the heap of waste by open fire releases bulk amount of dioxin, furan, CO_2, CO, soot particles etc and other hydrocarbons.

Environmental Fate of Plastic Waste

Variable modes of entrance of different plastic additives in our environment:

- From wastewater effluents during the production phase
- Via leaching and volatilization from plastic products during their use and after disposal
- Biotic and abiotic degradation of landfilled wastes

Plastic Waste Management

Today the management of plastic waste is a growing problem in many parts of the globe especially in the developing countries like India, Rapid urbanization and industrialisation has created pressure on basic amenities, resources, infrastructure, and in few areas the indiscriminate and injudicious waste disposal has created problems for the residents. Appropriate waste management is needed for better state of living conditions and environmental sustainability. Although, the steps are being taken worldwide for waste minimization and removal the pace is to be increased and scientific methods be implemented as per National and International norms.

Lack of proper management of plastic waste is the source of water, land and air pollution affecting the global environment and human health. At present the methods adopted for waste management are inadequate and too slow in comparison to the quantum of the plastic waste generated. The end of pipe solutions for the collection and disposal purposes is expensive requiring a high level technology. Such remedial measures are practically possible only in the industrially developed countries but not in the developing countries. An environmentally benign and eco friendly practice for the long term sustainability should be beyond the conventional measures adopted.

Plasma Pyrolysis Technology

This is a safe and effective method for the disposal of all types of plastics in an ecofriendly manner by integrating the pyrolysis process with the thermo chemical properties of plasma. In this technique the plastic wastes are pyrolised at a very high temperature generating carbon monoxide, hydrogen, methane, higher hydrocarbons, etc. These gases and the plastics waste are then subjected to combustion in presence of excess of air and ignited with high voltage spark. This results in the conversion of the hydrocarbon, carbon monoxide and hydrogen into carbon dioxide and water. The process conditions are maintained so that it eliminates the possibility of formation of toxic dioxin and furan molecules

Recycling of Plastics

Recycling of plastics can be one of the most effective and efficient practice for plastic waste management. It should be carried in a manner to minimize pollution during the process and enhance the efficiency by conserving the energy. Recycling of plastic waste should be done for producing a second generation plastic articles. The recycling technology is not a new concept but already a success in the developed countries due to proper co ordination between the consumers and the government agencies. This method can only be successful by creating awareness and support of the common masses. The Bureau of Indian Standard (BIS) has laid down specific guidelines for the safe plastic manufacture, usage and disposal. Also there are several national and international guidelines for the proper and ecofriendly segregation and recycling of the discarded plastic products. Respective BIS guidelines for the safer use of plastics include **IS:** 14534: 1998 for Codification of Plastics, IS: 9833: 1981 for Recycling of Plastic, IS: 14534: 1938 for Segregation of Plastic Waste. Practical implementation of these guidelines at the global level may lead to the safer and sustainable development of the plastic industry with clear market applications. We can use the recycled plastics for the development of models, educational aid materials and decorative items fabricated from waste plastic provided that they do not come in direct contact for packaging of foodstuffs or water.

Conclusion

Plastics can be considered as one of the most amazing inventions of the 20^{th} century and with continual improvements in 21^{st} century, having innumerable applications but the more it is used, the greater is the amount of waste generated. The "throw away practice" adopted by the common people has brought a menace to our environment and society. The need today is the mass awareness regarding the safer usage and disposal practices. Plastic recycling should be promoted globally and proper co-operation by the local masses can successfully implement the desired task for a sustainable environment. Waste generation cannot be prevented with the growth of humanity but its effective management is necessary from societal point of view. The methods selection may be from the success stories of its control or improvement practised worldwide. It may not be perfect today but with acceptability to adopt modifications with continual improvement(s). The successful technology is one which is based on scientific concepts, cost effective, easy to operate and understandable to masses. We must realize that the same technology may not be fully acceptable or adoptable in every region or situations.

DID YOU KNOW ?

1. The plastic wastes could be used in road construction and the field tests withstood the stress and proved that plastic wastes used after proper processing as an additive would enhance the life of the roads and also solve environmental problems. Waste plastic is made powder and three to four per cent plastic is mixed with the bitumen. Plastic increases the melting point of the bitumen and makes the road flexible. Plastic roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes. It is hoped that in near future we will have strong, durable and eco-friendly roads which will relieve the earth from burden of all types of plastic-waste.
2. Bottled water produces up to 1.5 million tons of plastic waste per year. According to Food and Water Watch [http://www.foodandwaterwatch.org/water/bottled], production of plastic requires up to 47 million gallons of oil per year to produce. Over 80 percent of plastic bottles are simply thrown away.

CURRENT CONCERNS

1. Not all recycled plastics go into new, recyclable products. Recycled plastic that goes into secondary products--such as plastic lumber and textiles--cannot themselves be recycled. This does not reduce the use of virgin materials in plastic packaging.
2. Our choice is limited to recycling or wasting. Source reduction is preferable for many types of plastic and isn't difficult. Opportunities include using refillable containers, buying in bulk, buying things that don't need much packaging, and buying things in recyclable and recycled packages.
3. The more serious problem with plastic waste concerns the additives contained in plastics. These additives include colorants, stabilizers and plasticizers that may include toxic components such as lead and cadmium. Studies indicate that plastics contribute 28 percent of all cadmium in municipal solid waste and about 2 percent of all lead.

REGULATORY TRENDS

Regulation of plastic waste, particularly manufacture and use of recycled plastic carry bags and containers is being done in the country as per "Recycled Plastics Manufacture and Usage Rules, 1999 and its amendment in 2003. According to these Rules:

1. No person shall manufacture, stock, distribute or sell carry bags made of virgin or recycled plastic bags which are less than 8 x 12 inches in size and having thickness less than 20 microns.
2. No vendor shall use carry bags/containers made of recycled plastics for storing, carrying, dispensing or packaging of food stuffs.
3. Carry bags and containers made of recycled plastic and used for purposes other than storing and packaging food stuffs shall be manufactured using pigments and colorants as per IS 9833:1981 entitled "List of pigments and colorants for use in plastics in contact with food stuffs, pharmaceuticals and drinking water"
4. Recycling of plastics shall be undertaken strictly in accordance with the Bureau of Indian Standard specification: IS 14534:1998 entitled "The Guidelines for Recycling of Plastics"
5. Manufacturers of recycled plastic carry bags having printing facilities shall code/mark carry bags and containers as per Bureau of Indian Standard specification: IS 14534:1998 (The Guidelines for Recycling of Plastics).
6. No person shall manufacture carry bags or containers irrespective of its size or weight unless the occupier of the unit has registered the unit with respective SPCB/PCC prior to the commencement of production.
7. The prescribed authority for enforcement of the provisions of these rules related to manufacturing and recycling is SPCB in respect of States and the PCC in Union Territories and for relating to use, collection, segregation, transportation and disposal shall be the District Collector/ Deputy Commissioner of the concerned district

As per BIS Classification, there are seven categories of plastics:

Symbol	Short Name	Scintific Name	Used In
1	PET	Polyethylene Terephthalate	Watter bottels, PET Bottles, etc.
2	HDPE	High Density Polyethylene	Milk/detergent Bags, Carry bags, Container etc
3	PVC	Polyvinyl Chloride	Cables, Pipes, Floorings etc
4	LDPE	Low Density Polyethylene	Carry bags, films
5	PP	Polypropylene	Medicine bottles, cereal liners, Packaing films etc
6	PS	Polystyrene	Foam Packaing, Tea Cups, ice cream cups, etc
7	O	Others	Thermoset plastics, Multilayer & Laminated Plastics, PUF, Bakelite, Polycarbonate, Melamine, Nylon etc.

ON THE LIGHTER SIDE

WHERE AIR POLLUTANTS COME FROM, ACCORDING TO INDUSTRY:

Sulfur dioxide

From too many people with too many tummy troubles eating too many eggs

Lead

From overly burdensome taxes on the rich, which have lessened their ability to buy fine lead crystal, the preferred method of lead sequestration

Methane

From the butts of left-wing cows chewing commie alfalfa they got from a pinko farm co-op

Mercury

From a series of secret space probes that were sent to planet Mercury by the Johnson, Carter, and Clinton administrations that have kicked up clouds of "mercury dust," which have now drifted back to earth

Carbon Dioxide

From living, green plants, of course, which exhale CO_2. (Anybody who couldn't come up with that one obviously hasn't spent enough time learning how to misrepresent scientific fact!)

ON THE WEB

http://www.cpcb.nic.in/Plastic_waste.php Plastic Waste Plastics Manufacture, Sale & Usage Rules,1999, Plastic manufacturing and recycling units, Re-use of plastic waste in road construction

http://www.polymerenergy.com/ Turning Waste Plastics into Renewable Energy, The Polymer Energy™ system is an award-winning, innovative, proprietary process to convert waste plastics into renewable energy.

http://www.wasteonline.org.uk/resources/InformationSheets/Plastics.htm Plastics recycling information sheet- types of plastic; what does the law say? Why bother? What you can do; hows, whats and wheres of recycling plastic; useful publications and contacts

http://www.epa.gov/osw/conserve/materials/plastics.htm Just the Facts ; How Plastics Are Made ; How Plastics Are Recycled; Benefits of Plastics Recycling; Markets for Recovered Plastics; Source Reduction/Lightweighting

CONFERENCES

Plastics Recycling 2011 Conference.

March 1-2, 2011
Sheraton New Orleans Hotel
New Orleans, LA
http://www.resource-recycling.com/plasticsrecycling.com/index.html

Plast India (International Plastic Exhibition and Conference) 2011

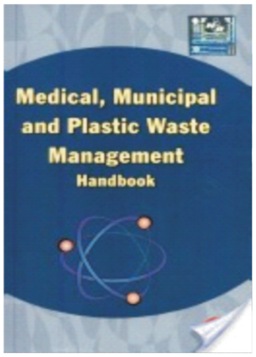
Feb 15, 2011
Pragati Maidan
New Delhi, India Past_Events | Future events
http://www.bvents.com/event/273364-plast-india-international-plastic-exhibition-and-conference

BOOK STOP

Plastic waste recycling technology

Author: Engineers India Research Institute. Board of Consultants & Engineers
Publisher: Engineers India Research In
ISBN 8189765302, 9788189765309
238 pages

The book 'Plastic Waste Recycling Technology' covers various methods including Introduction, Details of Polymers, Types of Plastics, Identification of Plastics, Recycling of Plastic Waste, Recycling of Thermosets, Chemical Recycling.



Medical, Municipal and Plastic Waste Management Handbook

Author: NIIR Board Of Consultants & Engineers
Publisher: National Institute Of Industrial Research
ISBN 8186623914, 9788186623916
544 pages

Waste management is one of the essential obligatory functions of the country. This service is falling too short of the desired level of efficiency and satisfaction resulting in problems of health, sanitation and environmental degradation. This book provides overview of the status of medical, municipal and plastic waste management. Treatment techniques includes sterilization, incineration and number of recycling methods.

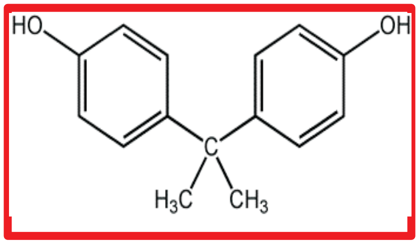
MINI PROFILE OF BISPHENOL-A

SYNONYMS: beta,beta'-bis(p-hydroxyphenyl)propane; 2,2-bis(p-hydroxyphenyl)propane; 2,2-bis(4-hydroxyphenyl)propane; bis(4-hydroxyphenyl)propane; dimethylmethylene-p,p'-diphenol-; diphenylolpropane-; 2,2-di(4-phenylol)propane; ipognox-88-; isopropylidenebis(4-hydroxybenzene); p,p'-isopropylidenebisphenol-; 4,4'-isopropylidenebisphenol-; p,p' parabis-a-; phenol,-4,4'-dimethylmethylenedi-; phenol,-4,4'-pluracol-245-; propane, 2,2-bis(p-hydroxyphenyl)-; rikabanol-; ucar-bisphenol-hp-

MOLECULAR FORMULA:
C_{15}-H_{16}-O_2

MOLECULAR WEIGHT: 228.28

MOLECULAR STRUCTURE



PROPERTIES: white flakes; mild phenolic odor; mp: 150-155^{0}C; bp: 220^{0}C; density/specific gravity: 1.195 AT 25^{0}C; soluble in ether, benzene, aq alkaline soln, alcohol, acetone; slightly soluble in carbon tetrachloride; water solubility: 120 mg/l at 25 ^{0}C; vapor pressure: *4X10-8 mm Hg at 25 ^{0}C

ANALYTIC LABORATORY METHODS: high-pressure liquid chromatography (HPLC)

USES: Intermediate in manufacture of epoxy, polycarbonate, phenoxy, polysulfone and certain polyester resins; flame retardants, rubber chemicals, fungicide.

OCCUPATIONAL SAFETY: Biphenol A is an endocrine disruptor. Occupational exposure to bisphenol A may occur through inhalation and dermal contact with this compound at workplaces where bisphenol A is produced or used. Monitoring data indicate that the general population may be exposed to bisphenol A via inhalation of ambient air, ingestion of food and drinking water and direct exposure via interaction with consumer products containing this compound as it is widely used in commodity packaging. A single clinical report describes photoallergic contact dermatitis to bisphenol A, with subsequent persistent light reactivity, in a group of eight outdoor workers.

METABOLISM: The metabolism and toxicokinetics of bisphenol A in humans exposed to low doses were investigated. Human subjects were administered d(16)-bisphenol A (5 mg). d(16)-Bisphenol A glucuronide was the only metabolite of d(16)-bisphenol A detected in urine and blood samples. d(16)-Bisphenol A glucuronide was cleared from human blood and excreted with urine with terminal half-lives of less than 6 hr; the applied doses were completely recovered in urine as d(16)-bisphenol A glucuronide. Maximum blood levels of d(16)-bisphenol A glucuronide (approximately 800 nM) were measured 80 min after oral administration of d(16)-bisphenol A (5 mg). bisphenol A is rapidly conjugated and excreted by humans rapid excretion of the formed glucuronide result in a low body burden of the estrogenic bisphenol A in humans following oral absorption of low doses.

TOXICITY DATA:

LD_{50} Rat (male, F344) oral 4100 mg/kg
LD_{50} Rat (female, F344) oral 3300 mg/kg
LD_{50} Mouse oral 2500 mg/kg
LD_{50} Rabbit oral 2230 mg/kg
LD_{50} Rabbit ip 150 mg/kg
LD_{50} Rabbit dermal 3600 mg/kg (24 hr-covered applcation)

ECOTOXICITY VALUES

LC_{50} Pimephales promelas (fathead minnow) 4.7 (4.0 to 5.5) mg/l/96 hr, static test

LC_{50} Pimephales promelas (fathead minnow) 4.6 (3.6 to 5.4) mg/l/96 hr, flow-through test

LC_{50} Menidia menidia (Atlantic silverside) 9.4 (8.3 to 11) mg/l/96 hr /Conditions of bioassay not specified/

PERSONAL PROTECTION: Wear protective gloves and clothing to prevent any reasonable probability of skin contact.

HANDLING AND STORAGE: Store away from heat and strong oxidizers and ... /strong bases, acid chlorides, and acid anhydrides. In the event of any leak evacuate the area and restrict entry of any persons not wearing protective gears. Remove all ignition sources. Vacuum cleaning is preferable to sweeping to keep dust levels down. Use special HEPA vacuum; not a shop vacuum. Ventilate area of spill or leak after cleanup is complete. It may be necessary to contain and dispose of this chemical as a hazardous waste. If material or contaminated runoff enters waterways, notify downstream users of potentially contaminated waters.

Route	Symptoms	First Aid	Target organ
Inhalation/ ingestion	Irritation in respiratory tract, sneezing	Remove patient to fresh air, provide oxygen, give artificial respiration, seek medical help	Respiratory system
Contact	Single contact may not produce any symptom, repeated exposure may produu ce irritation, in eye contact corneal damage is possible	Flush the affected part with water	Skin, eye

MAY WE
HELP YOU

To keep abreast with the effects of chemicals on environment and health, the ENVIS Centre of Indian Institute of Toxicology Research, deals with:

Maintenance of toxicology information database on chemicals

Information collection, collation and dissemination

Toxic chemical related query response service

Preparation of monograph on specified chemicals of current concern

Publishing Abstract of Current Literature in Toxicology

for further details do write to

Scientist In-Charge

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