Polyethylene Plastics (PEP): Considerations for Its Classification as a New Type of Persistent Organic Pollutants (POPs) from a Developing Country's Perspective.

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ABSTRACT

This paper presents the need for an urgent inclusion of polyethylene plastics (PEP), especially polyethylene bags, in the class of persistent organic pollutants (POPs). The Stockholm Convention on Persistent Organic Pollutants commits governments to reducing, and where feasible, eliminating the production and environmental releases of 12 POPs. PEP poses environmental hazards in developing countries. The evaluation of PEP in this paper satisfies to a greater extent all the information requirement and screening criteria for its inclusion in the class of POPs and further as a POP under the restricted group was justified from the evaluation of PEPs properties (physical, chemical and combustion by-products) and environmental hazards. It is anticipated that this classification would ensure the use of stricter regulation on the production, application and disposal of PEP in the environment.

(Keywords: Stockholm convention, POP, polyethylene bags, waste management, developing countries)

INTRODUCTION

This paper presents the need for an urgent inclusion of polyethylene plastics (PEP), especially polyethylene bags, in the class of persistent organic pollutants (POPs). This call follows critical assessments of definitions, properties, and the adverse human, animal, and environmental impacts of polyethylene bags in developing countries, particularly Nigeria. Further support for this lays in the underlined possibilities of amendments and further inclusion of any chemical in the class of POPs as suggested by parties to the Stockholm Convention on Persistent Organic Pollutants (SCPOP, 2001). Again, by support of the fact that emission of so-called "emerging" or "new" unregulated contaminants has emerged as an environmental problem, especially in developing countries, and there is a widespread consensus that this kind of contamination may require legislative intervention (Petrovic et al. 2008) to eliminate or restrict future pollution.

In Nigeria, as with the world over, factors such as increasing population growth rates, increasing urbanization, industrialization, and economic growth have led to increased waste generation. A simultaneous increase, with exponential proportions, is seen in the waste from PEP usage, which have become a major environmental menace due mainly to ineffective waste management systems (Achankeng, 2003; Kofoworola, 2006; Olu-Olu and Omotosho, 2007; Olanrewaju and Ilemobade, 2009).

However, while the existing definition of POPs depicts chemicals that are primarily in liquid or gaseous states, this paper charts a new scheme for POPs with respect to the PEP whose original state is solid. The basis of the scheme is the screening criteria in Annex D of SCPOP (2001). It is anticipated that this scheme would form reference material for further future works.

DEFINITIONS

Polyethylene Plastics (PEP)

For the purpose of this paper the term polyethylene plastics refer to products from the two main groups of polyethene, High Density Polyethylene (HDPE) and Low Density Polyethylene (LDPE) (Orica, 2005; KEMI, 2003).

Persistent Organic Pollutants (POP)

POP are chemical substances that possess toxic properties, resist degradation, bioaccumulate and are transported through air, water, and migratory species, across international boundaries and are ultimately deposited far from their place of release, where they can accumulate in terrestrial and aquatic ecosystems (SCPOP, 2001; UNEP, 2009).

RATIONALIZATION FOR PEB INCLUSION AS POP

Properties of PEP

Polyethylene, $(C_2\text{-}H_4)_n$ is manufactured from the polymerization of ethylene (C_2-H_4) (Figure 1). Basically, polyethylene is an odorless, translucent solid, commercially available in pellet form, which is convertible to derivative products such as the polyethylene bags. PEP are stable and inert polymers, exhibiting very high resistance to chemical attack including alkalis, aqueous solutions, non-oxidizing acids, and to a lesser extent, concentrated oxidizing acids. It exhibits excellent toughness and the ability to form strong resistance to heat, water, and water vapor. Other physical properties include an Auto-ignition Temperature or 90-130^{o}C and a Decomposition Point >250^{o}C (Orica, 1998; Ali, 2005).

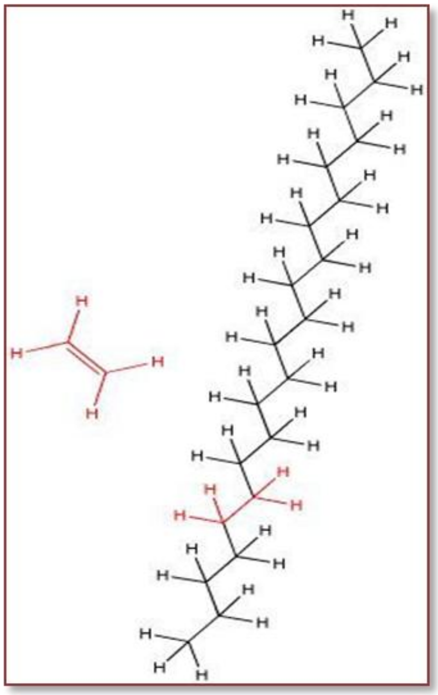

Figure 1: Polyethylene Structure.
Source: http://en.wikipedia.org/wiki/Polyethylene

Sources, Application and Emission of PEP into the Environment

PEP came into the market for commercial use in early 1982 (Ali, 2005) and has found its applicability in modern society due to its ease of use, hardiness, light weight, water proof nature, and low cost (Sharma and Kanwar, 2007).

There are municipal (residential, market, hospitals, etc.) and industrial (e.g., sachet water) sources of PEP that eventually get into the environment (Aziegbe, 2007). Ultimately, ineffective waste management systems are the principal form of activity that exposes PEP to the environment. Precursors to this are the random disposal of waste polyethylene, and due to its light weight, wind transportation in air is easily accomplished thereby achieving long range transport of this material.

PEP is used for folios/films, foils, household articles, carrier bags, table water sachet, ice cream containers, garbage bags, sweet and biscuit wrappers, pipes and hoses, coated papers (to render them waterproof), paints and adhesives (to act as the binder), and assorted consumer materials (KEMI, 2003; Ali, 2005; Aziegbe, 2007).

Impacts of PEP in the Environment

As mentioned earlier, some PEP products (e.g. carrier bags) are air borne and delocalized. One of the adverse impacts of this is the aesthetic impact from random litter on streets, trees, buildings, and poles, thus impairing the beauty of the environment.

Reports have indicated that PEP has had severe adverse effects on marine environments (notably the Great Pacific Garbage Patch), killing marine animals which choke on floating plastic items or by become entangled in plastic debris (Rutkowska et al. 2002; Wikipedia, 2009).

Environmental hazards created by PEP include soil and water contamination and closing of drains and sewerage lines in and around cities. Since polythene is non-degradable, it remains intact in water and soil for many years, choking otherwise productive soil (BBC, 2002; Ali, 2005; Sharma and Kanwar, 2007). Adverse effects on livestock have also been reported (Mohammed and Muhammad, 2007).

Open burning of refuse dumps in developing countries is a common practice (Izugbara and Umoh, 2004). It has been realized that if burned PEP products produce harmful toxins which can threaten air quality (UNEP, 2002; Sharma and Kanwar, 2007). Some of the toxic substances released include POPs such as hazardous dioxins (UNEP, 2002). Other thermal/oxidative degradation products of polyethylene (Table 1) in controlled conditions have been studied and consist of chemicals that are of human health and are of environmental concern (Sojak et al. 2006). The toxicological profiles for most of these chemicals are well documented by the Agency for Toxic Substances and diseases registry, ATSDR, USA.

Table 1: Identified Compounds of Polyethylene Thermooxidation at Processing Temperatures (264 – 289°C). *(Hoff et al. 1982)*

Carbon dioxide	Butanal	Water
Isobutanal	Ethene	Pentanal
Propene	Acetone	Propane
Methyl vinyl ketone	Cyclopropane	Methyl ethyl ketone
Butene	2–Pentanone	Butane
2–Hexanone	Pentene	2–Heptanone
Hexene	Formic acid	Hexane
Acetic acid	Heptene	Propionic acid
Heptane	Acrylic acid	Octene
Butyric acid	Octane	Isovaleric acid
Methanol	Hydroxyvaleric acid	Ethanol
Crotonic acid	Furan	Caproic acid
Tetrahydrofuran	Butyrolactone	Formaldehyde
Valerolactone	Acetaldehyde	Hydroperoxides
Propanol	Alkoxy radicals	Acrolein

SCREENING SCHEME FOR PEP INCLUSION AS POP

According to the SCPOP (2001), information requirements and screening criteria for any chemical substance to be evaluated for consideration as a POP include the chemical identity, nature of persistence, bioaccumulation, potential for long-range environmental transport, and adverse effects.

Figure 2 shows a schematic evaluation for the considerations of PEP as possible POP. The first row indicates the criteria as questions raised in the evaluation. Further rows present answers in line with conditions stated in the criteria (SCPOP, 2001). It can be seen that PEP satisfies to a great extent, all the evaluated information requirement and screening criteria.

Figure 3, again following the SCPOP (2001); indicates the placement of PEP into the three major groups by which POPs are generally regulated. The regulation acknowledges POPs as those to be eliminated, those which must be restricted in use and production, and those whose production are unintentional.

Considering the nature, properties and environmental impact of PEP, it was carefully placed in the group of those POP whose use and production are to be restricted. The restricted POPs are chemical products of acceptable purpose and may be granted specific exemption due to their significant uses, for example 1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane (DDT). However the usage of this chemical is strictly under high regulation that covers all areas ranging from production, application to disposal. This is the sought of regulation that all PEP product require as well, to protect human and the ecosystem from their hazards.

CONCLUSION AND RECOMMENDATIONS

The Stockholm Convention on Persistent Organic Pollutants (SCPOP, 2001), commits governments to reducing, and where feasible, eliminating the production and environmental releases of 12 POPs.

PEP especially the polyethylene bags poses environmental hazards. Its classification as POP under the restricted group is justified from the evaluation of PEPs properties (physical, chemical and combustion by-products) and environmental hazards.

This classification would ensure the use of stricter regulation on the production, application and disposal of PEP in the environment.

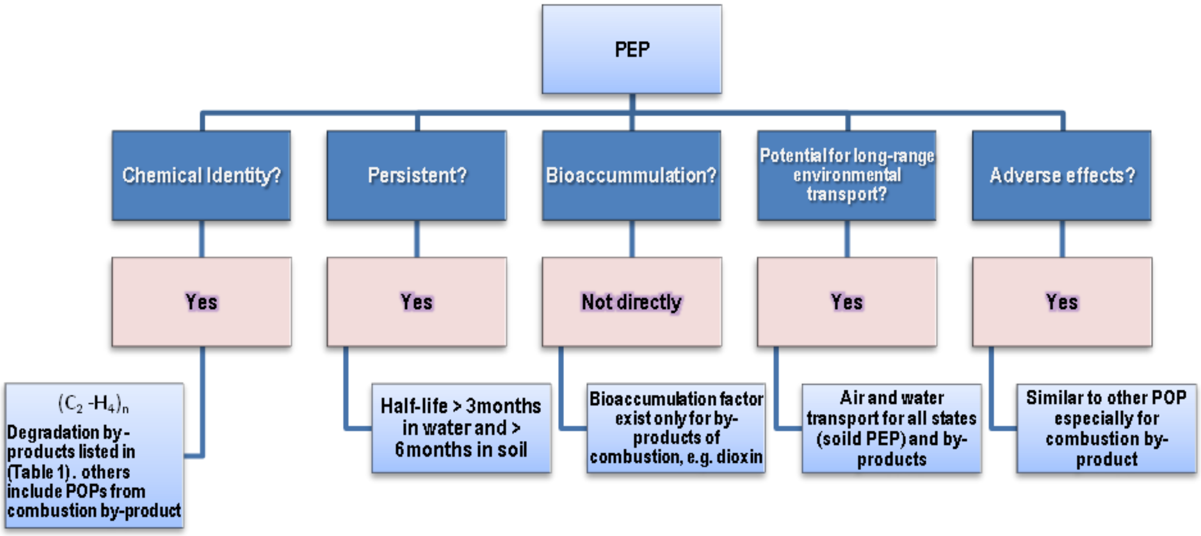

Figure 2: Evaluation Scheme for PEP Considerations as a Possible POP.

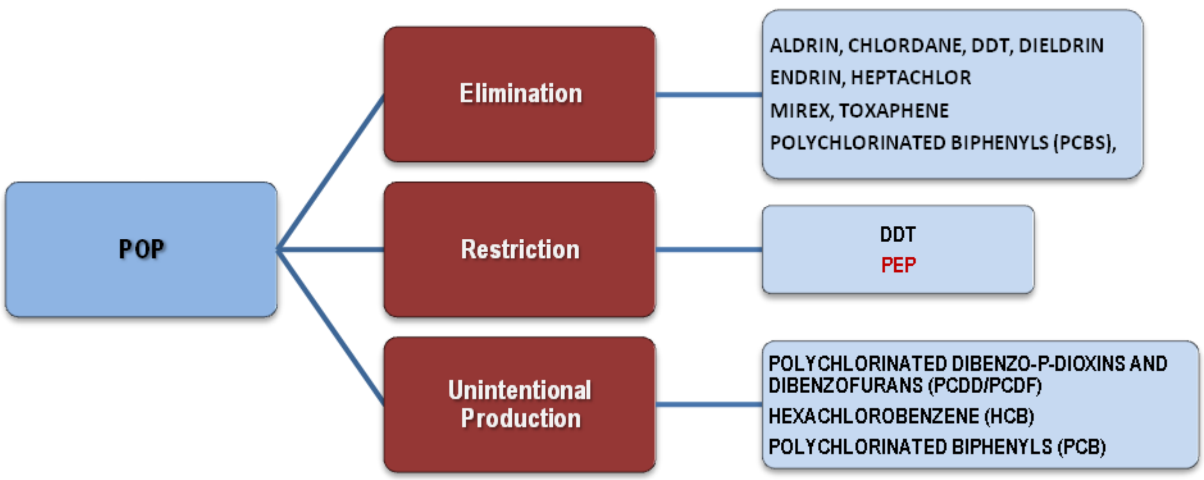

Figure 3: Placement Scheme for PEP in POP Group.

However, the regulation on PEP is anticipated to integrate significant developments in the area of waste management such as:

1. The development of biodegradable polyethylene plastics as suggested (Rutkowska et al., 2002)

2. Reuse of waste from polyethylene products such as the conversion of used sachet water bags for the production of candle (Edoga et al., 2007) and possible reuse of the catalytically degraded product into fuel oil (Jalil, 2002)

3. The reduction of waste by recycling activities (Olanrewaju and Ilemobade, 2009)

4. Placing a ban on the use of polyethylene bags similar to regulations

which have been imposed in India (Sharma and Kanwar, 2007) and Bangladesh (BBC, 2002)

5. Application of *Sphingomonas* bacteria which can degrade over 40% of the weight of plastic bags in less than three months (Wikipedia, 2009).

REFERENCES

1. Achankeng, E. 2003. "Globalization, Urbanization and Municipal Solid Waste Management in Africa African Studies". *Association of Australasia and the Pacific 2003 Conference Proceedings - African on a Global Stage.* 1-22

2. Ali, H.A. 2005. *Naturalist: The Polyethene bane*". New Age Online. http://www.newagebd.com

3. Aziegbe, F.I. 2007. "Seasonality and Environmental Impact Status of Polyethylene (Cellophane) Generation and Disposal in Benin City". *Nigeria J. Hum. Ecol.* 22(2): 141-147.

4. British Broadcasting Cooperation. 2002. "Bangladesh Bans Polyethylene". BBC Online. http://www.bbc.co.uk

5. Edoga, M.O., Onyeji, L.I., and Oguntosin, O.O. 2007. "Achieving Vision 20: 2020 Through Waste Produce Candle". *Journal of Engeneering and Applied Sciences.* 3(8): 642-646.

6. Hoff, A., Jacobsson, S., Pfäffli, P., Zitting, A., and Frostling, H. 1982. "Degradation Products of the Plastics: Polyethylene and Etyrene-Containing Thermoplastics - Analytical, Occupational and Toxicological Aspects". *Scand J Work Environ Health* 8, Suppl. 2:55-58.

7. Izugbara, C.O. and Umoh, J.O. 2004. "Indigenous Waste Management Practices among the Ngwa of Southeastern Nigeria: Some Lessons and Policy Implications". *The Environmentalist.* 24(2):87-92.

8. Jalil, P.A. 2002. "Investigations On Polyethylene Degradation Into Fuel Oil Over Tungstophosphoric Acid Supported On MCM-41 Mesoporous Silica". *Journal Of Analytical And Applied Pyrolysis.* 65: 185-195.

9. KEMI. 2003. *Polyethene: Information on Substance*. Swedish Chemical Agency: Sundbyberg, Sweden. http://www.kemi.se

10. Kofoworola, O.F. 2007. "Recovery and Recycling Practices in Municipal Solid Waste Management. Lagos *Nigeria Waste Management.* 27:1139–1143

11. Mohammed, A.K. and Muhammad, I.R. 2007. "Fatal Polyethene Bag Rumen Implication in Cattle at Shika – Zaria, Nigeria". Research Journal of Animal Sciences. 1(1):6-8.

12. Olanrewaju, O.O. and A.A. Ilemobade. 2009. "Waste to Wealth: A Case Study of the Ondo State Integrated Wastes Recycling and Treatment Project". *Nigeria European Journal of Social Sciences*. 8(1):7-16.

13. Olu-Olu, O. and Omotosho, B.J. 2007. "Waste Disposal and Waste Management in Ado-Ekiti, Nigeria". *The Social Science.* 2(2): 111-115.

14. Orica. 1998. Polyethylene Chemical Fact Sheet. Orica Limited, ACN 004 145 868.

15. Petrovic, M., Radjenovic, J., Postigo, C., Marina Kuster, M., Farre, M., López de Alda, M., and Barceló, D. 2008. "Emerging Contaminants in Waste Waters: Sources and Occurrence". *Hdb Env Chem*. 5(S/1):1–35.

16. Rutkowska, M., Heimowska, A. Krasowska, K., and Janik, H. 2002. "Biodegradability of Polyethylene Starch Blends in Sea Water". *Polish Journal of Environmental Studies.* 11(3):267-274.

17. Sojáka, L., Kubineca, R; Jurdákováa, H., Hájekovváb, E., and Bajusb, M. 2006. "GC-MS of Polyethylene and Polypropylene Thermal Cracking Products". *Petroleum & Coal.* 48(1):1-14.

18. SCPOP. 2001. "Stockholm Convention on Persistent Organic Pollutants, UN Document". May 22, 2001. SCPOP: Stockholm, Sweden. 1-34.

19. Sharma, N. and Kanwar, P. 2007. "Perception of Rural and Urban Homemakers Regarding Ban on Polythene Use in the State of Himachal". *Pradesh J. Hum. Ecol*. 22(4):309-312.

20. United Nation Environmental Programme. 2002. *Regionally Based Assessment of Persistent Toxic Chemicals* Sub-Saharan

Report. GEF. UNEP: Stockholm, Sweden. 11-13

21. United Nation Environmental Programme. 2009. “Persistent Organic Pollutants”. UNEP: Stockholm, Sweden. http://www.chem.unep.ch/pop/

22. Wikipedia. 2009. “Polyethylene”. *Online free Encyclopedia*. Wikimedia Foundation Inc. USA. http://www.en.wekipedia.org

23. Zitting, A. 1998. *Thermal Degradation Products of Polyethylene, Polypropylene, Polystyrene, Polyvinylchloride and Polytetrafluoroethylene in the Processing of Plastics*. The Nordic Expert Group for Criteria Documentation of Health Risks from Chemicals: Solna, Sverige. 1-46.

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