DISPOSAL OF SANITARY WEARS/NAPPIES IN DIFFERENT PARTS OF THE WORLD: A REVIEW

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Abstract : Solid waste is becoming one of the most challenging problems being faced by local municipal and urban authorities all over the world. It is seen that sanitary waste which includes sanitary napkins and baby diapers constitutes significant percent of the municipal solid waste. The sheer number of soiled sanitary waste discarded with general household waste every day adds to the burden of the environment. Sanitary waste are difficult to compost. Hence the preferred method of disposal of sanitary waste is incineration or dumping. However incineration produces pollution which itself poses challenges in environmental friendly disposal, while dumping causes threat to groundwater and land contamination.
Study presented here is a review of various methods used globally for the management of sanitary wears and its applicability to the Indian conditions.

IndexTerms **- Diapers, Sanitary napkins, Recycling, Landfills, Composting**

I. INTRODUCTION

Solid waste generation and management is an issue of big concern in modern societies. Developing countries face specific problems regarding it, due to social, educational and economic factors which do not allow application of state of the art technologies. Traditional waste management schemes, still used in many countries, are focused on confinement and landfilling; this strategy does not only use valuable land, but creates risk of dissemination of toxics in the environment. Waste recycling, on the other hand, promotes recovery of materials that can be used in new productive cycles, eliminating waste management requirements and saving natural resources (Rosa M. Espinosa et.al, 2014).
In recent years the continuous growth in waste generation has become one of the main environmental problems that modern society have to face. The increasing environmental awareness in society along with an increasing difficulty in locating waste facilities such as waste incinerators and landfills has lead public administrator to search for alternative waste management solutions such as composting or recycling (Joan Colón et.al, 2010).
In modern societies, sanitary wears/ nappies constitute a significant percentage of municipal solid wastes (Joan Colón et.al, 2013).They have been traditionally landfilled or incinerated as only limited recycling processes are being implemented in some parts of India. The use of napkins has increased in India in the last decades; in 1997, used sanitary wears/nappies were the 6% of urban waste, now this amount has increased up to 15% in some areas (Rosa M. Espinosa et.al, 2014). Due to their mixed organic–inorganic composition with the municipal solid waste, they are usually perceived as a problematic non-biodegradable waste; nevertheless, due to their high cellulose content they could be recycled biologically in order to recover the nutrients present in them (Rosa M. Espinosa et.al, 2014).
The sheer number of soiled sanitary napkins discarded with general household waste every day adds to the burden of the environment. A survey conducted in 2011 by market research showed that at 12 per cent, India has one of the lowest sanitary napkin usage figures in the world. The figure is 100 per cent in Japan and Singapore, 64 per cent in China and 88 per cent in Indonesia. Estimating that 300 million women in India are of 15-54 years of age, a sanitary napkin usage of 12 per cent implies that 36 million women use sanitary napkins every month. The lack of concern for sanitary waste management in our country is reflected in the fact that there are no reliable statistics available on the subject.
Diapers are used even in low income and rural areas. It has been determined that a baby can use up to 2190 diapers yearly. As per the survey, with a population of more than 5 million babies and toddlers between 0 and 2 years , more than 32 million of diapers are sent to landfills every day. As a used diaper weights an average of 210 g, more than 6800 tons of diaper waste, which will not degrade easily, are disposed on a daily basis. Impacts associated to disposal of diapers landfilling include land use, methane production and leaching of organic compounds to soil and groundwater. Biodegradation of diapers in landfills is highly improbable, due to the fact that they're usually disposed of wrapped in its plastic layer, and to the lack of enough biological activity in landfills (Rosa M. Espinosa et.al, 2014).
Different approaches have been tested to deal with sanitary waste. Sanitary wears can be incinerated along other organic wastes, but their combustion could lead to production of contaminants such as CO and chlorine compounds if not controlled properly; mechanical biological treatment has been applied to diapers in Spain, Italy and Germany; costly mechanical separation and recycling has been tried in the US, Asia and Europe (Rosa M. Espinosa et.al, 2014). The following table 1 shows the estimation of diapers used in licensed child care units by country;

Table 1: Estimation of diapers used in licensed child care units by different countries

Country	Used diapers (millions)
Denmark	252.21
Sweden	423.31
Norway	233.15
Finland	229.82
Netherlands	709.97
Belgium	487.00
France	3140.93
United Kingdom	3015.00
Portugal	400.74
Itlay	2199.33
Ierland	279.00
Austria	299.80
Hungary	375.55
Germany	2647.16
Czech Republic	455.20

Source: Source: Own elaboration based on Environment Agency (2004), OECD (2006) and Eurostat (2009).

This paper deals with the treatment techniques carried out for sanitary waste in different parts of the world and establish the same for Indian conditions.

II. DISPOSAL PRACTISES CARRIED OUT IN DIFFERENT PART OF THE WORLD:

Following data shows the practises carried out in different parts of world with their usage of sanitary wears/nappies products.

2.1 Mexcio: (Rosa M. Espinosa et.al, 2014)

According to a research paper (2011), diapers accounted for 6% of urban solid waste generated in Mexico in 1997 and in the range 5–15% in 2008 (M.Torrijos et.al, 2014) and was sent to landfills, as no alternative treatment or valorization options is available (Joan Colón et.al, 2010).

In Mexico, with a population of more than 5 million babies and toddlers between 0 and 2 years (INEGI, 2012), more than 32 million of diapers are sent to landfills every day. As a used diaper weights an average of 210 g more than 6800 tons of diaper waste, which will not degrade easily, are disposed on a daily basis. Impacts associated to disposal of diapers landfilling include and use, methane production and leaching of organic compounds to soil and groundwater. Biodegradation of diapers in landfills is highly improbable, due to the fact that they're usually disposed of wrapped in its plastic layer, and to the lack of enough biological activity in landfills.

In order to test the feasibility of composting used disposable baby diapers, these were composted using bioreactors along with yard waste. Diapers and yard waste was mixed and then was introduced in four drilled bioreactors (200 L each), made of high density polyethylene. Two reactors were filled with the diaper–yard waste mixture, and the other two used as controls, contained only yard waste. The resulting compost was tested for possible phytotoxic effects toward a selected plant species.

This study shows the feasibility of biological recycling of used diapers containing urine. The results of this research show that used disposable diapers can be introduced in the composting of yard waste, without negative effects on the process. The parameters used to assess this, such as pH, temperature, CO_2 production, moisture content, and C/N ratio had similar values for bioreactors with or without diapers. The resulting compost with diapers, achieved the parameters set in the local standard for the composting of organic waste, with the exception of pH values, which were slightly higher than the set limit. Presence of coliforms was below the limits of the local regulation, due to the effect of the temperature in the composting process. No phytotoxic effect was detected after growing tomato plants on compost.

2.2 Spain: (Joan Colón et.al, 2013)

Generally, diaper waste is composed of organic matter (cellulose pulp, faeces and urine) it is generally collected together within the refuse fraction and disposed of in municipal waste deposits. In this study, a full-scale composting of door-to-door collected organic fraction of municipal solid wastes (OFMSW) with a 3% (w/w) of compostable diapers has also been carried out. The objectives of the research were: (i) to analyse the biodegradability of two brands of available compostable diapers, (ii) to study at full-scale the performance of the composting process of used baby compostable diapers collected in a nursery with the OFMSW, and (iii) to evaluate the quality of the end product with and without diapers as control experiment.

Two lab-scale experiments were carried out in order to evaluate the biodegradability of two commercial compostable diapers (D1 and D2) during approximately 600 h. Along with these experiments, a control without diapers was also carried out. Unused diapers were utilized to carry out the lab-scale experiment and the experimental conditions adjusted for optimal composting. Both

mixtures (with and without diapers) were composted in the same static forced-aerated composting reactor for 41 days (active decomposition stage).

In lab-scale experiments, which can present some limitations compared to full-scale results, degradation values close to 45% of the initial carbon content were observed. The composting process of the OFMSW with compostable diapers at full-scale has shown no technical problems in the biological process in terms of stability, quality and sanitation of the resulting compost. No pathogenic microorganisms have been detected when composting compostable diapers, a relevant point when considering possible legal restrictions in the collection and treatment of the OFMSW containing used diapers.

2.3 France: (M.Torrijos et.al, 2014)

The French national survey on household waste conducted in France by ADEME (2010) highlighted that the sanitary textile fraction (including diapers, sanitary towels, tissue papers, cotton, wet wipes, paper towel, paper tablecloths and napkins, etc.) represented 9% by mass of total municipal solid waste, amounting to 34 kg of waste per inhabitant per year. Colón et al. (2010) estimated that the specific generation of waste from disposable diapers in Europe in 2007 was 4,278,461 tonnes which is 1.66% of total municipal waste generated and 3% of the organic fraction.
The aim was to divert used diapers from municipal solid waste streams and classic disposal methods such as incineration or land filling by designing an original approach involving material recycling and energy recovery. In this approach, used disposable diapers must be separated at source, collected separately and sent to an industrial center for treatment according to the process patented by Conway et al. The main steps are: coarse shredding, pulping and separation of plastics, separation of the super-absorbent polymer (SAP) and recovery of the biodegradable fraction of diapers (BFD). As this treatment process requires the use of large volumes of water, the industrial center could be set up at a wastewater treatment plant (WWTP) to optimize water use and further post-treatment. Indeed, the effluent at the outlet of the WWTP could be used in the treatment of the diapers and then recycled back to the start of the wastewater treatment line for pollution removal. Furthermore, the biodegradable fraction of diapers could be co-digested with waste activated sludge for energy recovery in pre-existing anaerobic digesters.

The work presented was part of the research programme aimed at evaluating the technical feasibility of the treatment at an industrial center of used disposable diapers for the recovery of their plastic fraction for recycling as raw material and of their biodegradable fraction for energy production.

The methane yield of the biodegradable fraction was found to be, as 150 kg of dry BFD are produced per ton of used diapers, the volume of methane which can be produced from 1 ton of used diapers is 40 m^3, corresponding to about 400 kW h of total energy and 130 kW h of electricity.

2.4 Europe: (Mauro Cordella s et.al, 2015)

With respect to the generation of solid waste, it should be considered that disposable baby diapers are estimated to constitute up to 2 - 3% of municipal solid waste (MSW) in Europe which is between 6% and 15% of the entire continent's waste. Production of disposable diapers in the European Union (EU) and Turkey has increased from about 18 000 million product units in 1997 to more than 22000 million in 2009, for a market value of about 5000 million euros.

A core role in the assessment of the environmental impacts of products is played by the Life Cycle Assessment (LCA) methodology, which is defined in the ISO 14040-44 standards. An assessment of the environmental aspects related to the life cycle of disposable baby diapers in Europe is presented paper with the aim of analysing recent improvements and identifying key environmental areas on which to focus in order to further decrease impacts. .An LCA for a disposable diaper based on biodegradable polymers showed that the environmental performance of the specific product under study was better than that of standard diapers, especially if composting is included as the end of life scenario in the assessment. The assessment has covered the product's life cycle from “cradle to grave” , which has been subdivided into four subsystems and was studied:

- S1. Production and supply of materials and packaging;
- S2. Manufacturing of the product;
- S3. Distribution;
- S4. Product disposal (End of Life).

Based on the elements collected during the study, effective measures for decreasing the environmental impacts of disposable baby diapers should be supported by an LCA and focus on product design, especially for optimising the use of materials with which to fulfil the expected functional and performance requirements. With respect to the end of life stage, incineration seems the best available option for this product group while alternative forms of treatment oriented to material recovery and recycling could require significant structural changes to the waste management system.

2.5 Germany: (R.stegmann et.al, 1993)

A cross-linked polyacrylate polymer, referred to as absorbent gelling material (AGM), has been developed for use in hygiene paper products, such as infants diapers (nappies). The fate & effect of this polymer were studied in laboratory models of landfill and aerobic composting. Tests were conducted in 120 litres reactors containing a mixture of solid waste only, and panty diaper pads. Controlled temperature and leachate recycle were used to accelerate the biological processes.

The following were the results obtained;

- Most of the AGM (>90%) remained in the diaper pad and surrounding waste under conditions simulating the acid and methanogenic phases of a landfill.

- Only a small fraction of the AGM biodegraded (0.5%) under methanogenic landfill conditions; biodegradation under acid landfill conditions was essentially nill.
- A few percent of the AGM (2-4%) appeared in the leachate. This material biodegraded under aerobic conditions.

Thus it may be concluded that, over 90% of the AGM remains in the diaper and surrounding waste, with little biodegradation, as expected, for a polymeric material. A few percent of the AGM appeared in the leachate, but these components are biodegradable aerobically.

2.6 Canada: (Rosa M. Espinosa et.al, 2003)

In Canada, urban centers have generated big volumes of used disposable diapers, which do not have a treatment method for their biological reuse. Besides, the garden residuals are also produced in big volumes and a small fraction undergoes compost processes. The composting can be carried out in piles or arrays in open field or in reactors, being this last option a quicker procedure than the conventional one at open field. The composting in reactor can be classified in two ways of operation: Static and dynamic (moving bed).

In the static systems the interaction among the particles of the mass remains without change all the time. The reaction begins with the load of the reactor with the material that will be fermented and it concludes with the exit of this as compost. In the dynamic systems, the fermentation is quicker due to the continuous mechanical mixture of the load. The retention time for the systems in reactor varies from 1 to 2 weeks, but in all there is a later period of curing from 4 to 12 weeks, after the period of active fermentation. The flow of air favors the aerobic conditions, reducing the possibility of generation of unpleasant scents, that is also achieved adding lime to the material in process. In this work the biodegradation to the used disposable diapers blended with garden residuals and sawdust was made in a cylindrical reactor based on a system with periodic agitation. pH, temperature, humidity and kinetic results of the loads were collected in order to know some of basic parameters to design horizontal bioreactors. The time of biodegradation of each load was of 28 days.

The biodegradation of disposable diapers showed that this process could be adapted with the condition of that diapers were mixed with pruning residuals and sawdust under aerobic conditions. Average conversions between 50 and 60 % were obtained and the composting was a function of the sawdust concentration. Concentrations of sawdust lower than 20% were recommended. The biodegradation reaction was obtained when the temperature increased up 60°C and the pH decreased at 5.8. At the end of the reaction, as a result of the biodegradation the organic matter decreased 56% and the concentration of nitrogen increased 48%.

2.7 USA: (Charles P. Gerba et.al, 1995)

Enteric pathogenic micro-organisms may find their way into domestic solid waste from many sources including the disposal of food, pet litter and diapers containing faeces. Common enteric pathogens associated with faeces include Salmonella, enteric viruses and the protozoan parasites Giardia and Cryptosporidium. If these organisms survive composting, they could present potential health risks. All of these pathogens can be transmitted via the fecal oral route by contaminated food, water or fomites.

The purpose of this study was to determine the occurrence of these pathogens in composted waste which contained soiled disposable diapers. In some of the municipal solid waste undergoing composting, the concentration of diapers was increased to enhance the probability of detecting pathogens if they survived composting. Compost samples from the normal municipal solid waste stream and the diaper-enhanced waste stream were analysed for *Sahnonella,* enteroviruses (polio,coxsackie and echo viruses), *Giardia.* and *CD'ptosporidium.*

In this study, the concentration of diapers in the solid waste to be composted was increased 2-4 fold to increase the probability of finding pathogens present. No infectious enteric viruses or intact viral nucleic acid could be detected in the compost. In addition, no intact *Giardia* cysts or *Co,ptosporidium* oocysts were detected. These results indicated that these disease-causing organisms were destroyed by the treatment process or were present in numbers below our detection limit. *Sahnonella* was detected in only one sample after 175 days of composting. However, none were detected after 175 days of composting. The presence of *Salmonella* may be due to the failure to uniformly attain sufficient temperatures to kill the *Sahnonella* throughout the piles during composting, or to recontamination from birds or other animals.

2.8 Japan: (Satoko Ishii et.al,2014)

Humans are exposed to dioxins mainly through food and other sources of dioxins in the food chain are the products of combustion mechanisms used in municipal, hazardous, and medical waste incinerators. Dioxins are also produced in a variety of industrial processes, such as the bleaching of wood pulps with elemental chlorine. Consequently, so-called chlorine-bleached paper products are often the subject of speculation regarding the potential risk of dioxins from consumer product use. There are several reports on the presence of dioxins in fluff pulp used as the absorbent core in sanitary products, and risk assessment has already been performed. It was reported that there is little risk of exposure to dioxins in tampons. In Japan, over 90% of menstruating women use sanitary napkins, which include pulp. Therefore, we performed this risk assessment study by measuring the levels of dioxins in fluff pulp used in sanitary napkins and by comparing the daily exposure volume of dioxins from sanitary napkins and the tolerable daily intake (TDI) from toxicity data.

Seven samples of fluff pulp used as the absorbent core in sanitary napkins were received from Unicharm Corporation (Minato-ku, Tokyo, Japan). The sample was analyzed with a gas chromatograph–high resolution mass spectrometer (GC–HRMS).

The results showed that the daily exposure volume of dioxins from napkins was very low compared with the dioxins from food, the atmosphere, and soil, and the fact that the daily exposure volume from sanitary napkins was 1666–29166 times less than the TDI indicated that the risk of exposure to dioxins in sanitary napkins produced in Japan was negligible.

III. CONCLUSIONS:

In India very little of scientific studies are carried out about such wastes including collection and proper disposal. The studies from the various parts of the world indicate awareness and better methods of sanitary wears disposals. Contrary to that, in India, majority of the practices are confined to the non-scientific land disposals.

The works carried out in different parts shows that landfilling is not a option for sanitary waste as it takes very long time to degrade on its own. Incineration is also not a preferred option to treat this type of waste, because the nappies or diapers contain moisture and hence the power required for burning it is more. Composting is considered as a preferred option to reduce the volume of this type of waste.

The above literature shows that the combination of household waste and sanitary waste gives good quality compost. Sanitary waste can be managed with different methods like aerobic composting, anaerobic composting etc.

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