

Solid waste management in metro cities

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(Received 5 May, 2021; Accepted 30 June, 2021)

ABSTRACT

In the whole world, every person uses solid materials. In general, for the fulfillment of new products, natural resources are used to manufacture new papers, and trees are cut. In this work, the authors want to make people aware about recycling and the importance of the management of solid waste (SWM). For doing this, a survey has been done in which 144 people have participated. In this survey, all age group people, all range of income person, all type of residents, including educated people have participated. After analyzing the result of this survey, it is concluded that the people are not aware of the socio benefit of recycling and managing solid waste. People are also not aware of the economic benefit of recycling although recycling may be an employment generated business and industry.

Key words : Solid waste management, Recycling of waste papers, Recycling of garbage, Awareness about recycling, Planning & Management about waste materials

Introduction

Management of solid waste means planning to manage the solid garbage generated by a city. The garbage which the municipal corporation collects becomes solid waste. The amount of this solid waste is increasing continuously. Solid waste may be classified as Domestic solid waste garbage, Pharmaceutical Industries, residual waste materials, construction waste materials, Sanitary waste materials, Plastic waste materials, glass waste materials, waste paper materials, chemical industries waste materials, radioactive waste materials, agricultural waste, electronic waste etc. Strong waste is laid out as disposed of strong divisions, produced from home has grown units, exchange focuses, business foundations, enterprises, horticulture, foundations, public administra-

tions and mining exercises. The Central Public Health and Environmental Engineering Organization, the Ministry of Urban Development's specialized wing, has characterized strong waste in fourteen classes' upheld supply, root, and waste. These huge homegrown waste, civil waste, business squander, institutional waste, trash, garbage, cinders, enormous waste, road sweepings, dead creatures, development and destruction squander, modern waste, bold waste and biodegradable contamination squander. A strong waste administration framework incorporates combination, isolation, transportation, interaction and removal of waste. Generally, each day 1,00,000 MT of waste materials are generated by the states in India.

A larger than usual city like Mumbai produces about 7000 MT of waste each day, the city creates

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concerning 5000 MT, and elective goliath urban communities like Pune and Ahmedabad produce squander inside the fluctuate of 1600-3500 MT each day. Gathering, preparing, moving and arranging this strong city waste is the duty of local metropolitan bodies in Bharat. Most local bodies' zone unit are pained to create affordable waste administration. Ongoing occasions like the shutting of landfills in Pune and the city and interaction plant in Thiruvananthapuram following fights by locals feature the extreme effect of helpless waste administration on general wellbeing and the environment. It is observed that Delhi and Mumbai develop maximum garbage among all cities of India. These cities create concerning 11,500 and 8,800 tons of garbage each day.

Waste Management

The controlling of spread out squander the board relies on the time of chiefs, storing, arrangement, transport or move, connection and evacuation of solid waste materials amazingly suggests that best keeps an eye on the difference in everyday prosperity, conservation, monetary, slick, planning, and unmistakable natural issues. To its degree, the solid waste organization joins coming up with the body, monetary, planning, and legitimate limits. Plans would possibly encapsulate advanced disciplinary relations among fields like general prosperity, town and neighbourhood considering, social science, geography, sociology, monetary issue, correspondence and insurance, demography, planning, and material sciences. Solid waste organization practices will differ for private and mechanical creators, metropolitan and provincial areas, and made and horticultural nations. The association of non-hazardous waste in metropolitan districts is that crafted by subject matter experts. Unexpectedly, the organization of dangerous waste materials is regularly the commitment of these UN associations to make it, as subject to the neighbourhood, public, and shockingly overall trained professionals.

Useful parts of the Waste Management System

There are six valuable pieces of the waste administration framework, as disclosed beneath:

1. Squander age: This envelope any exercises worried in trademark materials that are no longer usable and are either accumulated for orderly removal or discarded.
2. On location dealing with, capacity, and han-

dling: This identifies with exercises at the reason for squandering age, which encourages more straightforward arrangement. For instance, squander canisters are set at destinations that produce much waste.

3. Squander assortment: a significant piece of waste administration, this incorporates exercises like putting waste variety canisters, assortment squander from those containers, and amassing garbage inside the area and place the social affair vehicles are unfilled. Although the social affair part includes transportation, this is frequently typically not the most waste transportation phase.
4. Squander move and transport: These are the exercises worried about moving the waste from the local waste grouping areas to the territorial garbage removal site in goliath squander transport vehicles.
5. Squander cycle and recovery: This alludes to the offices, hardware, and strategies used to recuperate reusable or reclaimable materials from the waste stream and support the adequacy of various helpful parts of waste administration.
6. Removal: a definitive phase of waste administration. The exercises pointed toward the systematic removal of waste materials in areas like landfills or waste-to-energy offices.

Incorporated Management of Solid Waste

As the field of solid waste organization advances, courses of action are being taken a gander at extra dependably and exhaustively. SWM, for example, is an accomplice degree progressively more imperative term inside the field of the waste organization. It insinuates the choice and use of relevant organization undertakings, advances, and strategies to recognize unequivocal waste organization goals and targets. The U.S. Regular Protection Agency (EPA) communicates that ISWM contains squander stock decline, reusing, waste consumption, and landfills. These activities are drained, either accomplice degree instinctive or depicted. All things being equal, it's important to worry that higher strong waste administration programs are frantically needed in certain nations. Exclusively regarding a large portion of the waste created in urban communities and one-fourth of what's made in country zones is gathered. Globally, the globe Bank cautions that world waste may increment from 2016 to 2050 by 70th in a really the same old thing situation.³ in progress

endeavours to help the waste administration framework are imperative to preserve a solid human biological future.

Review of Literature

The concept of a smart city varies from place to place and country to country. However, there is no particular concept that defines the term smart city. The layout of smart cities depends on the level of development, willingness for reform, needs and aspirations of people living in the area. Since there is no particular definition that covers the term smart city so as per the need of dwellers, the urban planners focus on four different pillars, which includes development-institutional, physical, social and economic infrastructure

The concept of smart cities includes infrastructural development, but it also requires a neat, clean and green city. The green city concept had become an important parameter in the smart cities project.

The concept of the green city involves the transformation of cities into neat, clean and green cities:

It involves clean air (maximum reduction of air particles and emission)

- Rational use of energy (minimizing the irrational and wastage of energy resources)
- Creating green areas in the society.

Rapid Industrialization, urbanization, and population explosion are the main reasons for millions of solid municipal waste generation. Poor collection, transportation and unawareness among the public leads to accumulating municipal solid waste in cities. However, the deficiency of treatment facilities and methods is equally responsible for enhancing municipal waste accumulation.

The steps involved in solid waste management include different activities like generation, storage, collection, transport, processing, and garbage disposal. But in many cities, solid waste management includes generation of waste, collection, transfer of waste, and disposal. The management of solid waste is required infrastructure, proper treatment facilities, and upgrading all activities associated with it.

In a cloud-based smart waste management system, the waste bins will be fully equipped with sensors that notify about the waste level in bins and send the information to the cloud. The dustbins in most areas are always overflowing because of the generation of most waste rather than expected. These overburden bins lead to the spread of waste in

the nearby areas, leading to poor hygienic conditions in the surroundings. So to avoid this problem, the authors proposed IoT based waste management for Smart Cities. The dustbins are embedded with the device, which helps to determine the threshold capacity of the bin. The study, which involves using smart waste management with smart agriculture, was done by Bonga et al. 2018 and Aazam M 2016. The study demonstrated that there is a need for a smart system of waste management with smart agriculture. In cities, the smart system of waste management involves using sensors and the IOT for collection and tracking the route of collecting waste. The study suggests that sensors and the IOT can monitor the optimum water usage in farming, fertilizers, and production of crops.

The researchers studied that both public and government roles are important for effective e-waste management. The government should have strict regulations and certificates like stewardship to ensure the security and proper handling of e-waste.

Similarly, Kiddee *et al.* (2013) and Agarwal (2015) reviewed and suggested the different approaches and tools used to manage e-waste. In developed countries, several tools have been used for managing e-waste. The tools include analysis life cycle, material Flow, Multi-Criteria and Extended Producer Responsibility. The study proposed a need to develop eco-design devices, Recover and recycle materials, and suitable disposal of e-waste. They studied that the different regulatory bodies like law enforcement agencies, waste management, and environmental protection organizations manage pharmaceutical wastes. The study suggests that different methods are used for managing pharmaceutical waste are incineration, autoclaving, microwaving, chemical disinfection, deep burial, waste immobilization: encapsulation (Sharma, 2005 and Shivashankari, 2016).

Similarly, another study was done by Kadam *et al.* (2016) and Muhammad, (2017), on pharmaceutical products. The study suggests the different methods for proper disposal of medication, expired and unwanted medical products. The study suggests the different methods used for proper disposal of various pharmaceutical dosage forms and different medical products.

Rios *et al.* (2018) and Sivakumaran (2013) reviewed the management innovation in foodservice industries in waste management. The strategies of waste management are based on incremental and

radical innovations. The initiatives in food service depend on the knowledge, goals and action.

The study on solid municipal waste was done by Pamnani *et al.* (2014) and Bong (2018). They reviewed the quality and management of solid municipal waste in certain cities of India. The paper suggests that current regulations are stringent. The deficiency in handling municipal waste management is short of finance, lack of planning, leadership, and training.

Similarly, a study was done by Joshi *et al.* (2016) and Parkash (2016) in which they studied the challenges and status management of solid waste in different cities of India. This study already suggested that decentralization of solid waste processing units in cities and the recycling industry's development are required in developing countries.

Material and Methods

In this work, the authors have tried to aware people about recycling waste papers and materials. A survey is being done to know about the fact of recycling of used materials and papers. In this survey, 144 people have participated in different characteristics. The criteria to differentiate the people are age, gender, residence style, education level, occupation type, monthly income, and style through the domestic garbage. All kinds of participants with the information of participation ratio are tabulated in Table 1. The questionnaire of this survey with response has been tabulated in Table 2.

After discussion with the people, the authors are proposed the following:

To study the management of waste materials, some planning is given in this manuscript.

Collection of waste materials: Waste materials which in general sell to the waste collection shop are collected and should be classified by the shopkeepers. The various waste materials like waste and used plastic bottles, waste papers, thick cartoon papers, scrapped iron materials etc should be separated and sent to the concerned industries. In these industries, the waste materials should be maximum reused or recycled as possible.

Style of collection of waste materials: Nagar Nigam of any district is collecting the waste garbage from home. In general, Nigam dumped all the materials in a trenching ground. All the waste materials become again waste, and the city becomes dirty.

The people become disturbed during the rainy season as in humidity various types of jumps are generated. Suppose classifications of all types of garbage are practically done and sent to the concerned industries for reuse or recycling. In that case, amount of garbage becomes decrease and landfill pollution also comes down.

Use of waste materials in handmade papers: The waste materials that could not be reused in any industry can be used to make handmade papers. The use of wet waste garbage may increase the quality and strength of papers.

Small collection centre of school/college: The collection centre given in Figure 1 represents that the small centers have individual sections for various types of garbage. The various types of garbage are collected in various sections and send to the big centre in section-wise.

Ward wise collection centre of garbage in the city: In the given picture (Fig.2), a photo of the collection is given, representing no individual sections inside the centre. The total garbage collected from the city is assembled inside this centre. The various types of garbage coming from small collection centres are assembled in the main centre, but working to differentiate the garbage becomes useless in a big centre. Various types of waste materials:

The waste materials obtained from multiple raw materials are given below. Organic waste materials are obtained from the remaining food in our homes and restaurants etc. Agricultural and animal wastes are also part of organic waste materials. Used newspapers, packing materials, tissue papers and used office papers will be converted into waste papers. Used polythene carry bags, and plastic toys are converted into plastic garbage. Tins, cans of soft drinks produce metal waste materials. Used glass bottles become the waste glass materials. Rubber, leather and cloths are the other types of waste materials. The used and waste clothes, demolishing building materials, waste paints are the miscellaneous waste materials. Other types of waste materials are e-waste. The used electronic items like TV, computer, laptop, music systems, mobile phones etc., produced e-waste.

Organic → Food waste, yard waste (grass trimming), wood, animal dropping
 Paper → Cardboards, newsprint, office paper, tissue paper
 Plastic → Polyethylene terephthalate (PET),

	high-density polyethene,
	Polyvinylchloride,
Metals	→ Scrap, cans and tin
Glass	→ Colored and plain
Rubber	→ Shoes and rubber & leather
Textiles	→ Clothes
Inert Ash	→ sand
Miscellaneous	→ Batteries, paints, construction and demolishing waste
E-waste	→ The used electronic items like TV, computer, laptop, music systems, mobile phones etc.

Results and Analysis

The survey has been done for people of different cat-

Table 1. Socio Economic-demographic characteristics of the study of SWM Number of participants (n = 144)

Characteristics	Number of participants, Percentage (%)
Age category (years)	
Less than 20	34 (23.61)
20 to 50 yrs	64 (44.44)
50 yrs and above	46 (31.94)
Gender	
Male	63 (43.75)
Female	81 (56.25)
Residence	
Own house with own roof	67 (46.52)
Apartment or flat	31 (21.52)
Rented house	19 (13.19)
Rural	27 (18.75)
Education	
Up to metric	39 (27.08)
Up to intermediate	28 (19.44)
Graduate	41 (28.47)
Post Graduate and above	36 (25)
Occupation	
Government employee	53 (36.8)
Private employee	23 (15.97)
Own business	35 (24.30)
Low scale industrialist	19 (13.19)
Others	14 (9.7)
Monthly income	
Upto Rs. 10,000/-	28 (19.44)
Rs. 10,000/-to 50,000/-	54 (37.50)
Above Rs. 50,000/-	62 (43.05)
Disposal of waste materials does	
Nearby waste bin	43 (29.86)
Inside the waste bin	37 (25.69)
Near home	23 (15.97)
Open field	41 (28.47)

egories. The socio-economic-demographic characteristics study has shown that 23.61% of people have participated whose age is less than 20 years, 44.44% people participated whose age is between 20 to 50 years. About 32% of people have age above 50 yrs respectively. The variation of percentage of participation is given in Fig. 4.1. As this study is done for public awareness about waste management and recycling waste papers, various types of questions are put from multiple people. In this study, 43.75% male and 56.25% female have participated. The percentage variation of male and female is shown in Fig. 4.2. The people from various locations were selected. 46.52% people having their own house, 21.52% from the apartment flat, 13.19% from the rented house, and 18.75% from the rural area participated in this study. This variation is representing in Fig. 4.3. People of different education level had participated in this study. 27.08% people participated whose education level up to matric, 19.44% people participated whose education level was up to intermediate, 28.47% people were up to graduate level, and education level of 25% participated people were postgraduate or above in this study. The variation of education of participated people is shown in Fig. 4.4. In this survey, 36.8% government employee, 15.97% private employee, 24.30% people doing own business, 13.19% small scale industrialist, and 9.7% others participated in this study. Fig. 4.5 represented the variation of percentage of participants having various employment.

For this study, the people of different income group participated. 19.44% of people have selected whose monthly income was less than Rs.10,000/-, 37.50% whose income level was in between Rs. 10,000/- to 50,000/-, and 43.05% people whose income group was above Rs. 50,000/-. The variation of participants of different income group was given



Fig. 1.

Table 2. Characteristics regarding solid waste management and recycling of waste materials among the study participants (n = 144)

Think about the utilization of recycling of waste material	
Yes	49 (34.02)
No	95 (65.98)
Trying recycling or utilizing in past	
Yes	54 (37.97)
No	90 (62.03)
Think about the usefulness of utilization of waste material and papers.	
Yes	86 (59.49)
No	58 (40.51)
Think the reuse or recycling of waste materials due to increase price of products	
Yes	26 (17.72)
No	118 (82.28)
Think the reuse or recycling of waste materials due to protection of water pollution	
Yes	33 (22.78)
No	111 (77.22)
Think the reuse or recycling of waste materials due to protection of the environment	
Yes	67 (46.83)
No	77 (53.17)
Think the reuse or recycling of waste materials due to protection of air pollution	
Yes	60 (41.77)
No	84 (58.23)
Do you know the increase in consumption of papers responsible for the reduction of forest	
Yes	127 (88.60)
No	17 (11.40)
Has media-aware to the people for recycling of waste material	
Yes	35 (24.05)
No	109 (75.95)
Do you know how many times paper can be recycled	
Yes	18 (12.65)
No	126 (87.35)

in fig. 4.6. It was also surveyed that how people dispose of their garbage. It is observed that 29.86% of people dispose of their nearby garbage dustbin, 25.69% of people used the dustbin to dispose of their waste material, 15.97% thrown near home, and

**Fig. 2.**

28.47% of people throw the waste material in an open field and the variation which represented the various percentage of the way of disposal is representing in Fig. 4.7.

In the next survey, the questionnaires were prepared so that participants only respond in the form of yes and No. All the above participants had responded to the questionnaire in the form of Yes and No, and it was tabulated in Table 2. It is analyzed that 34.02% of people accepted and 65.98% of people not accepted that they think about recycling waste papers, and this variation is representing in fig. 5.1. 37.97% of people were trying to recycle, and 62.03% were not trying to recycle the waste materials in the past. The curve which represents this variation is represented by fig. 5.2. In the discussion about recycling, it was also observed that 59.49% of people were aware of the benefit of recycling. However, 40.51% were not aware of that, and the variation which shows the variation of percentage of

people know about the benefit of waste management is given in fig 5.3. We all know that the prices of the products are increasing continuously. 17.72% recycled the waste materials due to an increase in the original price, and 82.27% were not doing this. The graphical representation of the given variable is shown in fig 5.4. The productions of new papers by paper industries are responsible for water and air pollution. This survey observed that 22.78% of people were recycling the waste materials to protect water as for manufacturing new papers, a lot of water is required. The variation of percentage is shown in fig 5.5. The recycling of waste papers is also our need due to environmental protection. As per 46.83% of people, we should recycle solid waste material to protect the environment and the variation is given in fig 5.6. 41.77% want to recycle the papers to reduce air pollution as in new paper manufacturing responsible for air pollution. The

curve which represents the variation of participated people is shown in fig 5.7. In this survey, 88.60% of people agree to recycle solid material to decrease forest reduction (fig 5.8). In the above matter, many conferences/seminars have been organized by many educational institutes and NGOs, but the role of media in this direction is very low. 75.95% of people accepted that media is not playing a good role in this direction, and shown by graphical fig 5.9. When it is surveyed that how many people know about the frequent recycles of the papers. Only 12.65% of people know that waste papers may recycled seven times. The curve which represents the variation of percentage of participants known about the above information, is given in Fig. 6.

The lifetimes of decomposition of various materials are different. Table 3 represents the decomposition timing of different waste materials

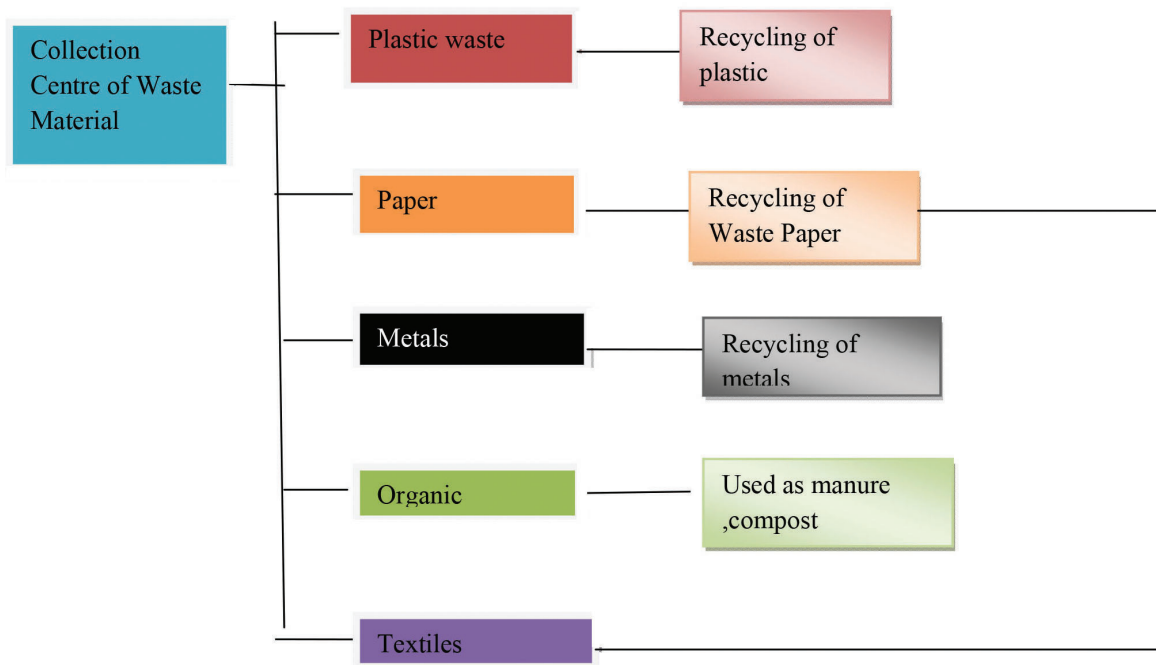


Fig. 3.

Table 3. Decomposition of waste materials

Used cartoon packing materials	About 4 weeks
Used old news papers	About 8 weeks
Used empty tetra packing materials	About 14 to 16 weeks
Waste and used plastic bags and bottles	15 to 20 years
Waste container of plastic films	More than 20 years
Waste rubber sole of shoes	More than 5 years
Waste plywood	More than 2 years
Remaining cigarette butt	About 2 to 5 years

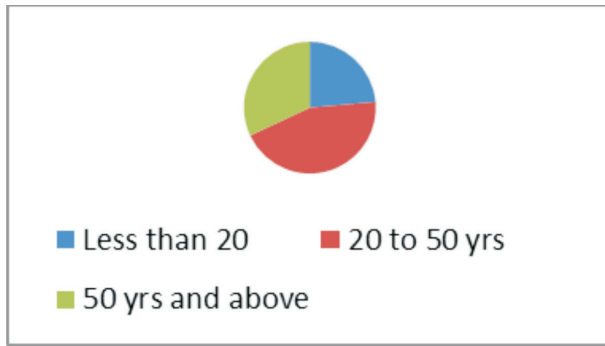


Fig. 4.1

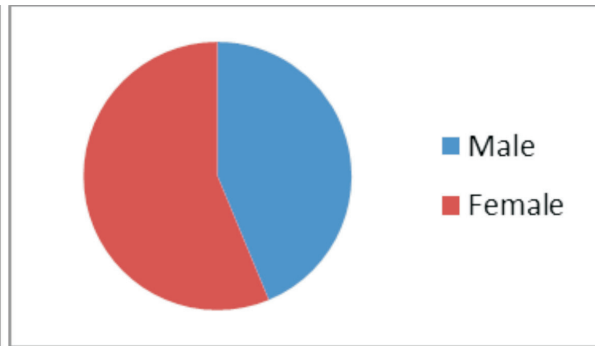


Fig. 4.2

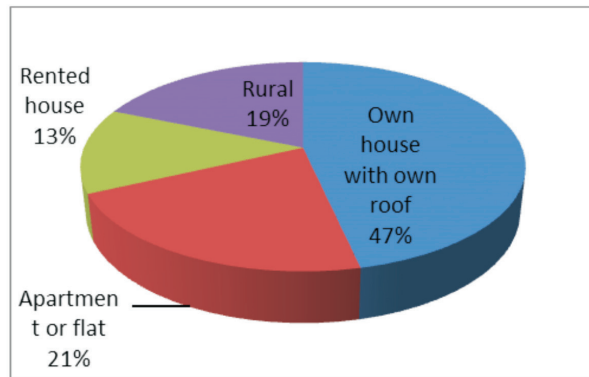


Fig. 4.3

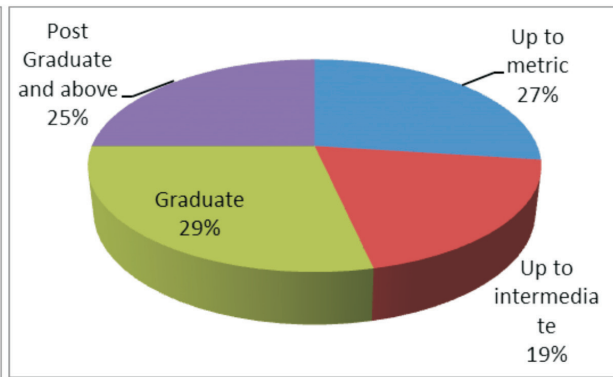


Fig. 4.4

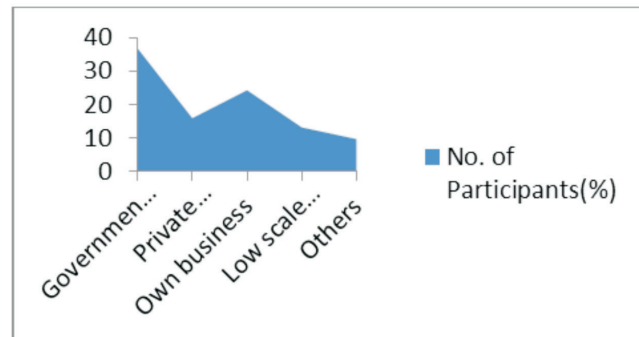


Fig. 4.5

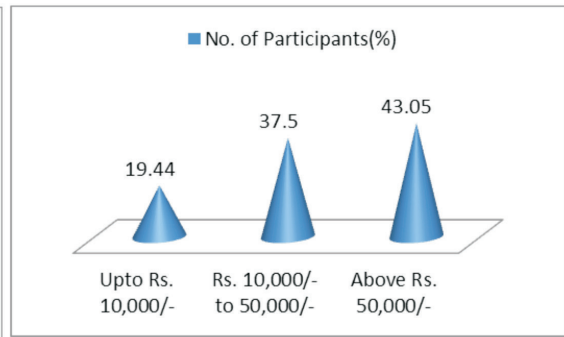


Fig. 4.6

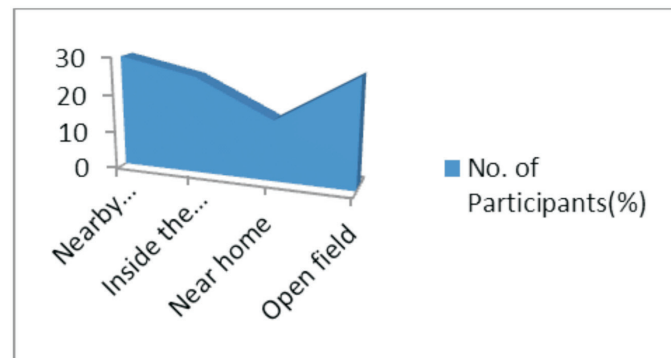


Fig. 4.4

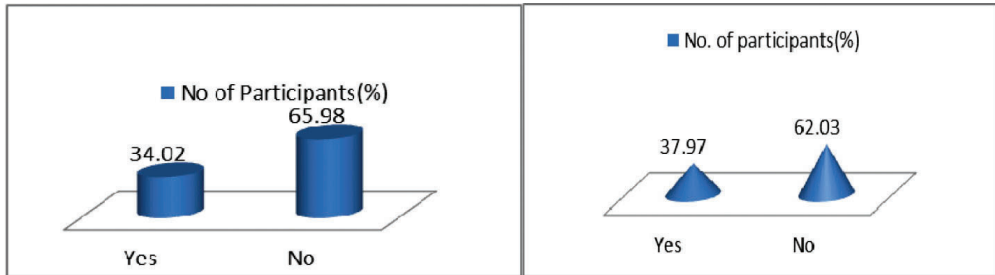


Fig. 5.1

Fig. 5.2

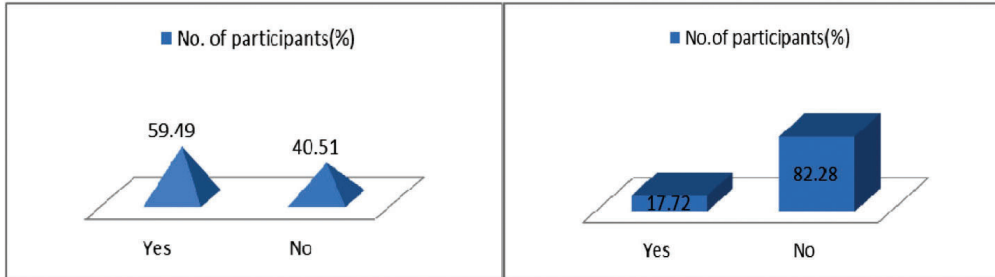


Fig. 5.3

Fig. 5.4

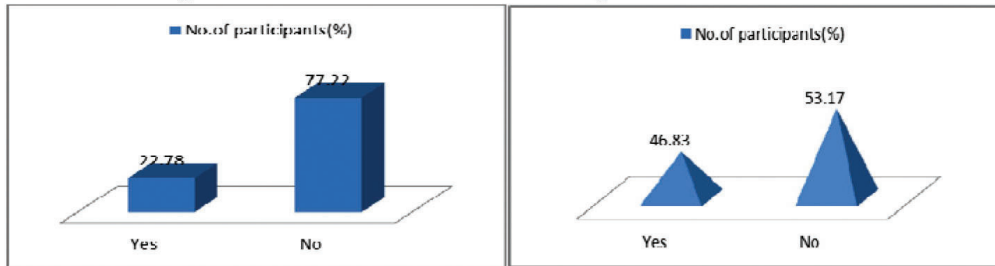


Fig. 5.5

Fig. 5.6

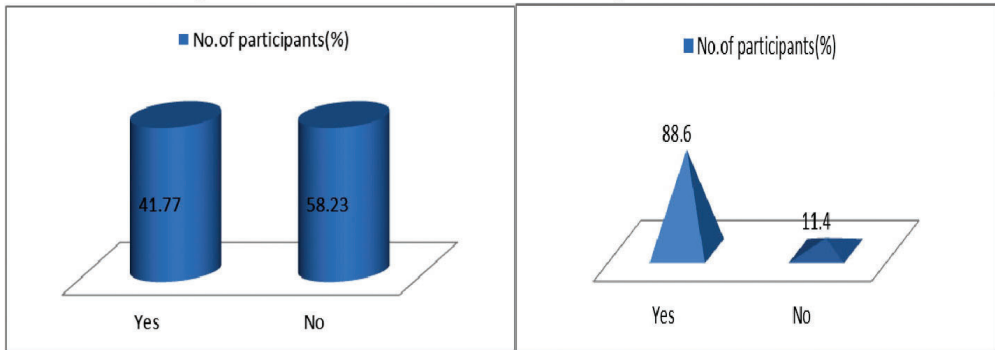


Fig. 5.7

Fig. 5.8

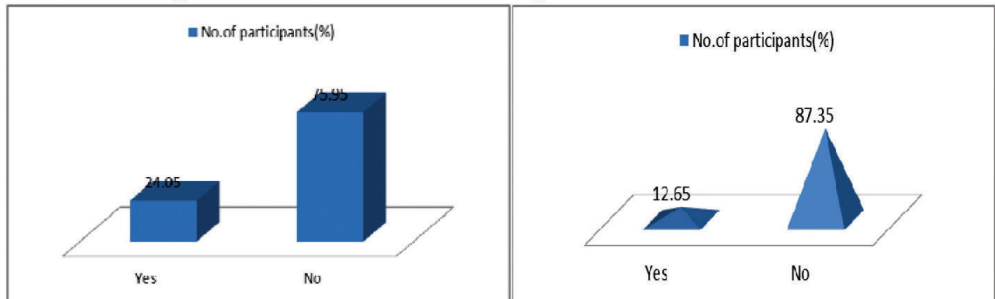


Fig. 5.9

Fig. 6.0

Conclusion

From the above results and discussion, it is concluded that recycling waste papers and solid waste management should be mandatory for the entire municipal corporation in all the countries. Recycling waste papers and materials is not only providing socio and economic benefit, but also it is useful for environmental protection. To know solid waste management, a survey in which all age category, residence, education, occupation people have participated. It is concluded that maximum people are not aware of recycling and solid waste management; however, they know that recycling is helpful for environmental protection, air, water and land pollution control. People know about the socio benefit of recycling, but they are not aware of the economic benefit. If the municipal corporation does the research and development in solid waste management, it becomes beneficial for the environment and society. The invention in this area may produce employment.

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