Public acceptance study of environmentally suitable landfill sites

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The present study was conducted to understand the public attitudes and preferences of location and operation of environmentally suitable solid waste landfill sites in Dhanbad city, Jharkhand, India. The research methodology used for obtaining data includes extensive questionnaire (prepared using the reported literature) survey and interview of the population. Statistical analysis (Pearson residuals and chi-square test) was done to understand the relationships among the responses received from the surveyed people of the study area. Most of the respondents (90%) were in favour of construction of engineered landfill sites, but many (70%) were not willing to pay any extra charges for solid waste management related services. This study will help the municipal authorities to identify a mechanism to gain public acceptance of the selected landfill sites and adapt the approach presented here to similar locations elsewhere.

Keywords: Landfill sites, public awareness, population survey, solid waste management, statistical analysis.

IN India, the number of organized and scientifically planned municipal solid waste management (MSWM) systems is limited. Segregation of waste is done mostly by the unorganized sector (scavengers and rag pickers), and rarely by waste generators at source. In most Indian cities, solid waste is directly disposed of without treatment in low-lying areas, at the outskirts of cities, alongside roads, etc. Door-to-door waste collection is partially practised in a few cities; community bins are generally used in India for collection of waste. However, these bins are either properly designed or not adequate in number; also they are not kept at proper places. Hence, people who find these bins beyond their reach, dump their waste anywhere they can.

Acceptance of landfill sites for solid waste disposal is a major challenge in society despite siting environmentally appropriate landfill sites considering all environmental and economic factors. Lack of proper spaces for landfilling and gaining social acceptance are major limitations for constructing a new landfill facility for solid waste disposal[1]. This becomes even more imperative for communities with practically no prior knowledge about solid waste management (SWM) facilities. Environmentally sustainable, economically feasible and socially acceptable SWM facilities are expected to be easily welcomed[2,3]. Landfill siting is not an easy task to accomplish because the site selection criteria depend on various factors, rules and regulations[4,5]. It is important to recognize apprehensions and awareness of people related to and affected by the location and operation of SWM facilities for a better communication with citizens and effective SWM[1]. Recently, the Dhanbad Municipal Corporation (DMC) started awareness programmes on SWM among the residents using various means such as wall paintings, print media and loudspeakers.

Public involvement in waste management planning has been sought in many municipalities across the world due to rising awareness. However, the present waste management scenario does not allow public participation in decision-making processes in many cities. Public dissatisfaction may lead to closure of a project, due to existence of intended risks because of locating SWM facilities or when the nearest residents (people who are most likely to be negatively affected) are concerned about the risks. Communication gap and/or lack of awareness among the authorities and residents may deter the acceptance of such facilities at the grass-roots level[6]. Therefore, it is obligatory for the concerned authorities to explain about the intended risks to the residents at the earliest during decision-making or selection processes to devise methods to minimize them. Responsible authorities (municipal authorities, public/private agencies, NGOs, etc.) must act quickly to resolve the concerns of all the stakeholders. The exchange of knowledge and opinions by involving local people during the decision-making process will provide a solution to the associated risk. Thus, active public participation and support are necessary to create an effective MSWM system with least environmental and social impacts[7]. The benefit of public participation in MSWM planning has been observed in some municipalities recently. A public opinion study was carried out in Tanzania to assess waste services provided by the local Government[8]. Peoples' preferences showed that they were satisfied with the current SWM services provided by the Government. However, due to lack of regulatory measures to support public involvement, there is no mechanism of exchanging ideas, concerns and information in India. Public involvement in the decision-making

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process allows them to express their views and helps the decision-makers to consider their opinions and concerns, thereby increasing the accountability and transparency of the processes[9].

The unscientific solid waste landfill sites in Dhanbad city are a major environmental problem as unsegregated solid wastes are dumped in any available low-lying areas in the city. The benchmarks for selection of sites had not been established and the concerns of people have been ignored[10]. There are several problems associated with the operation of landfills[11]. Almost half of the respondents indicated undesirable environmental impacts as a major problem due to landfills, whereas about 10% of them were bothered about the visual appearance of the sites. Trapped gases such as hydrogen sulphide and other trace gases inside landfills are responsible for bad odours, whereas trapped methane gas is responsible for landfill fires. These problems create adverse risks to the safety, health and welfare of the public in nearby areas apart from environmental issues. Site selection is one of the most difficult tasks in any landfill planning. There are various factors that need to be considered for site selection of solid waste landfills among which the opinion of local residents is the most important, as many potential sites have been eliminated due to this reason.

The objective of this study was to analyse data related to the concerns of people about SWM facilities and to identify the most important criteria that are to be addressed before development of landfill sites. For this purpose, key variables (known as concerns in this study) were identified from the literature that may influence public acceptance. A questionnaire was designed to identify priorities of the collected variables and their interrelations. Next the relationships amongst the variables and personal attitudes towards SWM facilities were analysed. A similar study was carried out in China to enhance public acceptance for waste incineration projects without considering the opinions of key stakeholders such as policy makers, developers and local Government[12]. However, for the present study, the questionnaire was designed considering the regulatory guidelines of the local bodies and Central Government for construction of new landfill sites. The study has highlighted the concerns and acceptance level of the public for environmentally suitable solid waste landfill sites in Dhanbad city.

Data and methodology

Study area

Dhanbad city, chosen as our study area is located in the state of Jharkhand and is known as the coal capital of India. It lies between 23°37′3″N and 24°4′N lat. and between 86°6′30″E and 86°50′E long. (Figure 1). The SWM facilities are provided by DMC, which is divided into 55 administrative wards[13]. The total area of DMC is around 355.77 km^2. As of 2011 Census, Dhanbad has a population of around 1.2 million. Estimates by DMC indicate that around 440 tonnes of municipal solid waste (MSW) is generated every day[13]. Figure 1 shows the location of the study area and the selected environmentally suitable landfill sites, Landfill site 1 was considered as the most suitable among all the 11 sites for the present study. The landfill sites were selected on the basis of suitable environmental factors[14].

Questionnaire design

The questionnaire was designed to assess the public attitude, concerns and awareness towards landfill facilities. It consists of 22 questions that are appropriate for the demography of the study area. Extensive literature review was used to frame each of the questions, to check their reliability and consistency for the study area[15]. The questionnaire was divided into two parts to collect information from the respondents. The first part was used to assess basic information of the respondents such as age, occupation, education, income, number of family members, etc. whereas the second part was used to acquire knowledge on the concerns related to various aspects of SWM facilities, such as landfill.

Survey design

The questionnaire was distributed among the residents of the study area. The target groups of the survey were those people who were aware of the SWM problem, people who were literate but do not have much awareness about the impact of SWM, and people who were illiterate and unaware of the problem. The respondents were asked a few basic questions on MSWM (segregation of waste, municipal services, etc.) before handing over the questionnaire to gauge their knowledge related to SWM. A detailed field survey was conducted for a better understanding of the nature of waste[16]. The survey was done among those residing within 500 m radius of the existing landfill/dump sites, irrespective of the population group they belonged to, since these people are expected to get maximum exposure and hence their concerns would play an important role in finalizing the selected landfill site.

Statistical analysis to determine public concern for SWM

A total of 150 people were contacted from different parts of the study area to participate in the questionnaire survey. Among them, 18 were not keen to participate in the survey; these were mostly from good educational background, but were not aware of SWM-related problems.

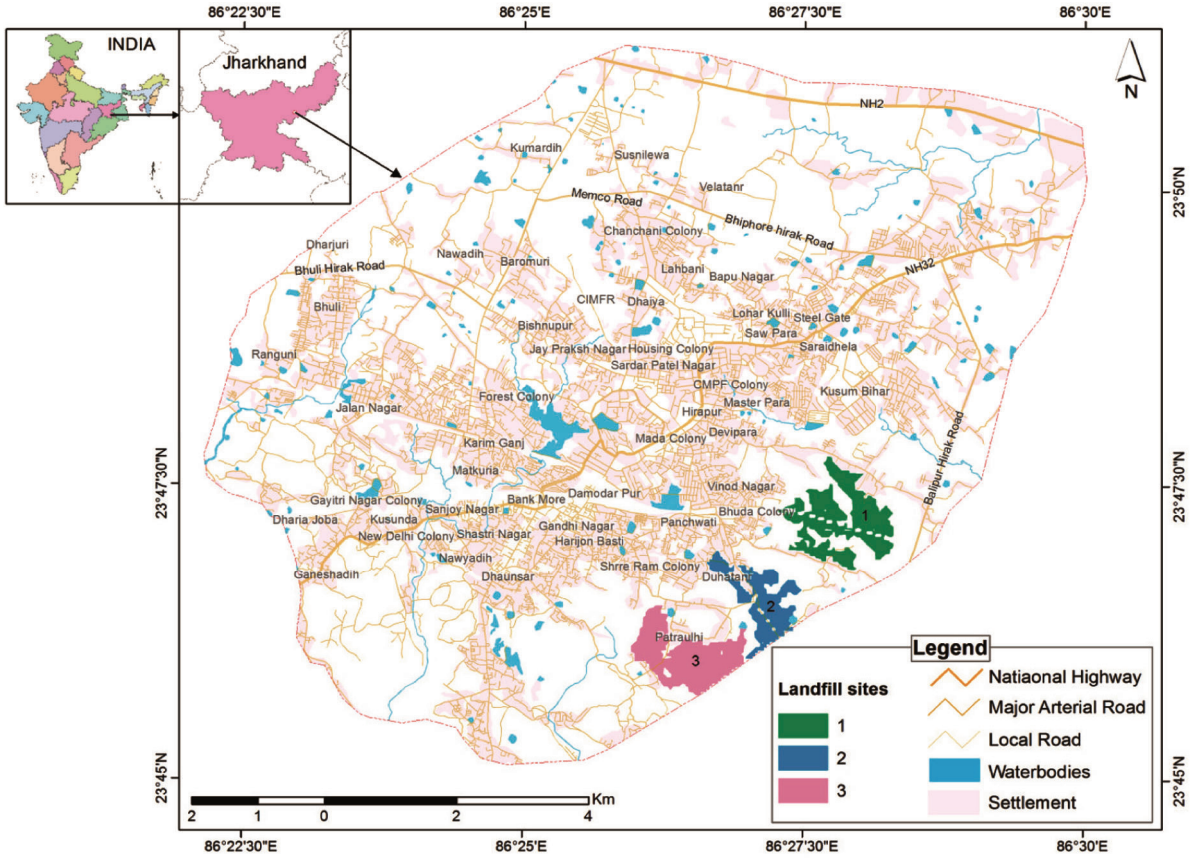

Figure 1. Location of the study area.

So, these people were excluded from the study and responses of the remaining 132 people were considered. The respondents were both males and females of different age groups (i.e. 20–30, 30–40, 40–50 and above 50 years). The interviewed people had different educational background (namely standard 8 pass, standard 12 pass, graduate and postgraduate), different occupational structure and income groups. The personal profile of the population of the study area was considered to address the concerns of people regarding SWM facilities.

Statistical analysis was done to better understand the concerns. Pearson residuals measure the departure of each cell from independence. The sum of the square of the departure is the overall Pearson χ^2 value. Empirically, the Pearson residual (r_P) is represented by eq. (1)

$$r_P = \frac{O_f - E_f}{\sqrt{E_f}}, \tag{1}$$

where O_f is the observed frequency and E_f is the expected frequency.

The maximum of the residual values is used to identify the cell responsible for dependency (eq. 2)

$$M = \text{Max} \mid r_{P_{ij}} \mid, \tag{2}$$

where $r_{P_{ij}}$ is the Pearson residual for all individual cells. Given a critical value of c_α by consulting the chi-square (χ^2) probability distribution table for the test statistic M, the null hypothesis of independence is rejected for all residuals whose absolute values exceed c_α at α level of significance[17]. Thus, the dependency of the cells can be identified using Pearson residual.

Chi-square (χ^2) test for dependency was applied to determine the socio-demographic influence on public response towards SWM facilities. It is used to determine whether there is a significant association between the two categorical variables or not[18,19]. According to usual practice, a smaller significance level ($P < 0.05$) was adopted, which implies more evidence that the null hypothesis H_0 (no significant association) is false and the alternative hypothesis H_1 (significant association/dependency) is true[20].

Results and discussion

The responses obtained during the survey were statistically analysed. Let us now discuss the relationships between the concerns related to landfill sites and responses of people.

Table 1. Questionnaire for population survey

Question	Level/answer
Personal profile	
Gender	Male, female
Age (yrs)	20–30, 30–40, 40–50, above 50
Occupation	Government employee, business, daily wager, student, other
Education	8th pass, 12th pass, graduate, postgraduate
Annual/monthly income	<Rs 1 lakh, Rs 1–3 lakhs, Rs 3–5 lakhs, >Rs 5 lakhs, <Rs 10,000, Rs 10000–40000, >Rs 40,000
No. of members in the family	<3, 3–4, 5–6, >6
Concern for MSW	
How do you feel about the present practice of solid waste management in the city?	Poor, satisfactorily, good, very good
How frequently does the solid waste get collected from your house?	Daily, alternate days, once a week, not fixed
How is the collection from the source to the community bin done?	House-to-house collection, own or by maid, simply to the backyard
Do you want a landfill in the city?	In favour, opposed, not concerned, not sure
How much are you worried about the atmosphere being polluted by emission from a facility?	Worried, slightly worried, not worried, not sure
How much are you worried about the stench and noise of collection vehicles?	Worried, slightly worried, not worried, not worried at all
How much are you worried about the traffic accidents caused by collection vehicles?	Worried, slightly worried, not worried, not worried at all
Do you think it will affect the aesthetic view of the city?	Very much, slightly, not much, not at all
Have you ever visited any disposal site?	Visited, just seen from outside, never seen, not sure
If landfill is constructed in the area about 1 km from your house, do you agree or oppose it?	In favour, not concerned, opposed, not sure
Is it unfair to receive and treat waste from other area in your area?	Unfair, slightly unfair, not unfair, not sure
If a special tax is levied on each household in the city annually, how much you will be ready to pay?	<Rs 1000, Rs 1000–2000, Rs 2000–3000, >Rs 3000, no tax at all
Which type of waste to be disposed in this landfill is acceptable to you?	Only household waste, municipal waste, municipal waste + construction and demolition waste, any waste
Do you want to have a recycle unit along with the landfill?	Yes, no
Are you eager to participate in planning?	Yes, no, not sure
Which parameter(s) is/are most important for selection of landfill from environmental point of view?	Groundwater pollution, soil pollution, air pollution, distance from settlement, all of the above, others
How much are you worried about the nuisance created due to landfill?	Worried, slightly worried, not sure

Peoples' concerns about the present MSWM practice

The questionnaire was designed to address the concerns of people about the present unscientific SWM scenario (Table 1). A majority of the respondents (about 90%) considered the present MSW practice to be poor, while only 10% were satisfied with the practice. A mixed response was received from the survey regarding solid waste collection system. According to the survey results, 34% of the respondents mentioned that waste was collected from their houses through the service provided by the municipality, a whopping 56% mentioned that they dropped the waste into the community bins by themselves or through their maids, while the remaining 10% people threw their waste in the backyard. The reasons are: (i) poor coverage by municipality for door-to-door waste collection; (ii) 70% of the respondents were not willing to pay for SWM-related services such as door-to-door collection, and (iii) 65% of the respondents were from lower and lower–middle socio-economic background who expect free waste collection service from the municipality. The people who threw their waste in the backyard were mostly daily wagers (Figure 2). The respondents who received door-to-door collection service provided by the municipality were asked about the frequency of solid waste collection from their houses. Around 52% of the respondents mentioned it was daily, 30% alternate days and about 18% said there was no fixed schedule. These responses were occupation-dependent. A majority of the Government employees said that the solid waste gets collected daily (Figure 3). In contrast, most of the daily wagers mentioned that there was no fixed schedule of waste collection.

Figure 3 shows the relationship between education and occupation of the respondents. The respondents who are daily wagers are not highly educated as most of them are standard 8 pass. Similar trend was observed for business class as high Pearson residual was observed for the respondents of business class who are standard 12 pass. Thus, high Pearson residual for daily waters and business class shows that education influences the occupation of the respondents. The government employees were mostly graduates, while most of the postgraduates respondents were students. Figure 4 shows that there is a dependency between occupational classes and their respective concerns about the adverse impacts of landfill on the environment.

The business class generally gave more importance to the distance from settlement as the most important environmental parameter to be considered for selecting a landfill. The Pearson residual for the corresponding tile is greater than 2, which signifies that this dependency is accepted at 0.05 level of significance as a rule of thumb. Whereas occupational class 'other' considered all of the criteria (soil pollution, water pollution, distance from settlement, etc.) as important.

Attitude of citizens towards landfills for solid waste disposal

Installation of SWM facilities is one of the biggest challenges faced by the municipal authorities. Landfills are widely used in developing countries for waste disposal and most of them are unsanitary landfills that create problems for the health and environment of the area. The study area does not have any demarcated engineered landfill site. The attitude of respondents towards construction of a new landfill site was positive (Figure 5).

Majority of the respondents (about 90%) expressed their concerns on the present situation of SWM in the city; hence they accepted the construction of a new landfill facility. A small percentage of the respondents (2%) opposed it, while 8% were not sure; they might be sceptical or did not clearly understand the problem associated with unscientific management of solid waste. About 44% respondents showed a 'concerned' attitude and 22% showed 'very much concerned' attitude towards installation of a recycling facility along with the landfill. In general, the attitude of citizens depends on knowledge about a facility and they tend to have a negative attitude towards unfamiliar facilities about which they have no knowledge. So, the lack of awareness of SWM among the people was found as the major reason for opposition. Responses were obtained from both males (56%) and females (44%) with different educational background. Also, 45% of the respondents were in the age group 40–50 years, 30% in the age group 20–30 years, and only

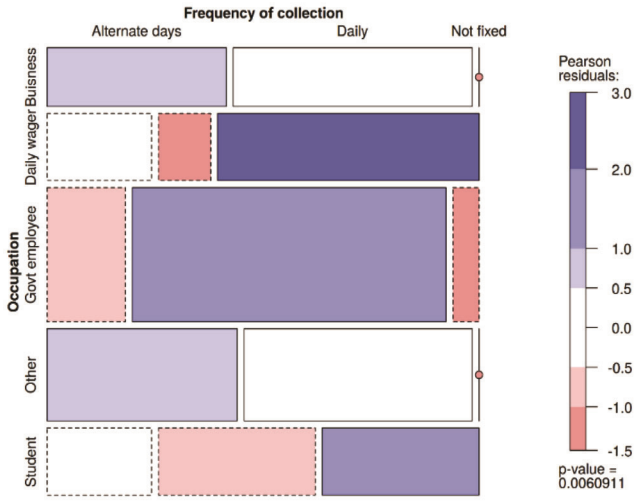

Figure 2. Influence of occupation on collection frequency of solid waste.

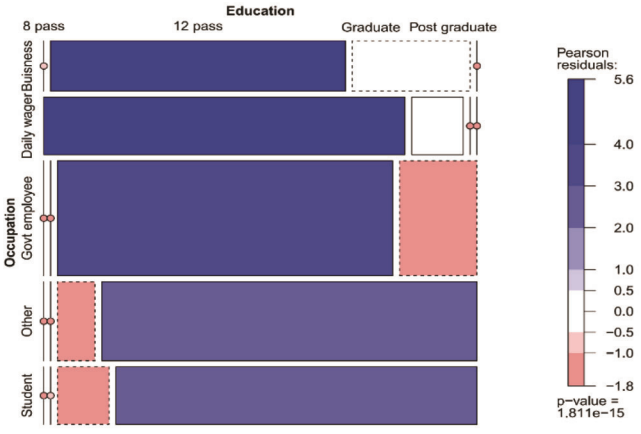

Figure 3. Relation between education and occupation of the respondents.

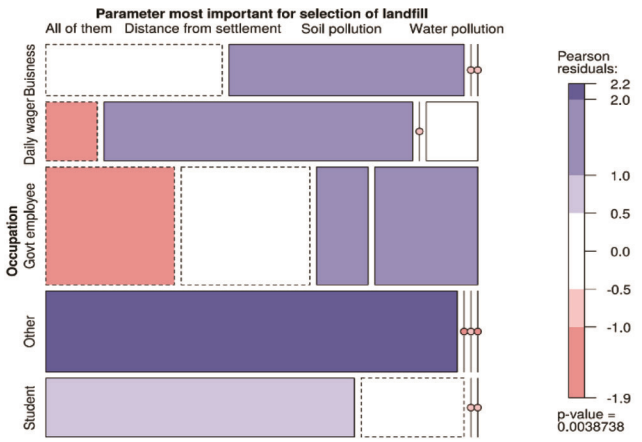

Figure 4. Relation between occupation and response of respondents on environmental impacts.

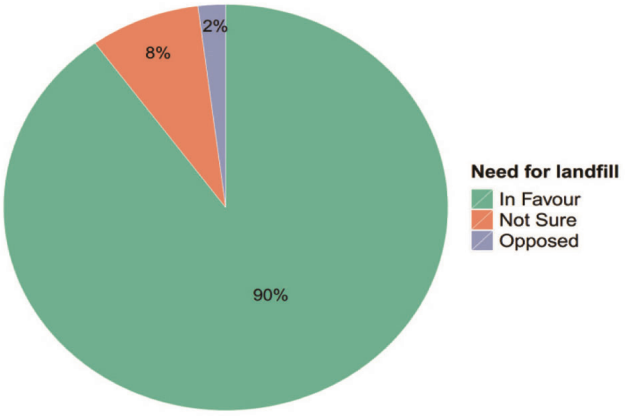

Figure 5. Acceptance of landfill as a new solid waste management facility.

10% were in the age group above 50 years. In terms of educational background of the respondents, 40% were graduates, 25% were 12th pass, 20% were 8th pass and the remaining 15% respondents were postgraduates. Based on the responses, it can be inferred that educational background of the people and awareness related to SWM are not directly proportional. Most of the highly educated (graduates and postgraduates) people were not aware about the problems caused due to poor SWM. The respondents from the age group 20–30 years (mostly students) were aware of the SWM-related problems and were in favour of a new landfill site.

Views of citizens about the adverse impact on environment and livelihood

The response of residents to the questionnaire related to the concerns about environmental pollution showed their apprehensions towards impact of SWM processes (Table 1). About 62% of the respondents were worried about the atmospheric pollution from the facility, while 32% of the respondents were not worried, and only 2% of the respondents were slightly worried. Most of the respondents mentioned that stench and noise of the collection vehicles may affect their daily lives. About 50% of the respondents were worried about traffic accidents caused due to movement of collection vehicles. The questionnaire survey related to aesthetic view of the city (which would be changed due to the allocation of solid waste collection bins and associated activities) revealed that about 50% of the respondents considered that the aesthetic view of the city would be negatively affected. Female respondents reported higher level of concerns on this issue (Figure 6). Majority of the respondents (90%) opposed a landfill near their homes (or within a radius of 1 km), because of the expected nuisance such as foul odour, unaesthetic condition and the problems related with stray animals. Majority of the respondents felt it is unfair to receive and treat wastes which is brought from other areas in their area. According to the respondents, groundwater pollution, soil pollution, air pollution and distance from settlement were found to be important criteria for selection of landfill sites.

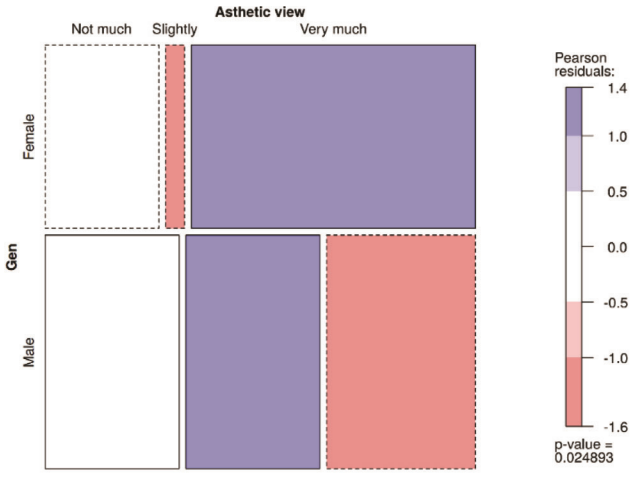

Figure 6. Gender-specific perception on aesthetic view based on present practice of solid waste management in the study area.

Willingness of citizens to participate in the SWM process

With regard to special tax for the proposed SWM services, about 70% of the respondents opted 'no tax at all', whereas about 30% were ready to pay some minimum tax. The reasons for this negative response are the poor socio-economic condition (education, income, occupation, etc.) of the respondents and lack of awareness related to SWM. The findings of a previous study carried out in Baranagar Municipal Area, Kolkata city, India, revealed that 50% of the respondents were ready to pay for a new waste management facility[21]. In the present study area, some of the respondents were not ready to pay special tax for SWM as they were already paying various other taxes to the local Government.

Correlation between personal attribute and present SWM practices

The surveyed data were cross-verified for likely interrelationships between the personal attributes of respondents and their answers to the different types of questions. The results of the χ^2 test showed that the relationships were significant (Table 2).

Figures 7 and 8 present some observations on the χ^2 test results. The occupational structure of the respondents played a significant role in the responses related to the present collection frequency of solid waste. The relation was statistically significant at 95% confidence level ($P = 0.01$). The responses of the daily wages group with 8 standard pass or lower educational qualification revealed that they simply throw solid waste in the backyard. This relation was also statistically significant ($P < 0.01$). These people have limited knowledge and awareness regarding contamination, waste reduction techniques and other aspects of SWM. The family income of the respondents was found to be an important factor for the responses related to payment of special tax for bringing new SWM facilities and maintenance of existing ones. The lower-income group respondents were not eager to pay, whereas only around 50% of the higher-income-group respondents were ready to pay the nominal amount with statistically significant interrelationship at 95% confidence level ($P < 0.02$), because problems related to SWM were not the causes of concern for them. Again the same factor influenced the present collection system, which

Table 2. Results of the χ^2 hypothesis test for independency

Variable	Gender			Age			Occupation			Education			Monthly income		
	χ^2	df	p-value	χ^2	df	p-value	χ^2	df	p-value	χ^2	df	p-value	χ^2	df	p-value
Present practice	5.10	2	0.08	12.22	6	0.06	1.80	8	0.99	1.75	6	0.94	1.40	4	0.84
Frequency of collection	2.30	2	0.32	6.87	6	0.33	21.43	8	0.01	10.95	6	0.09	16.18	4	<0.01
Collection process	0.55	3	0.91	6.49	9	0.69	37.54	12	<0.01	39.44	9	<0.01	26.23	6	<0.01
Need for a landfill	1.39	2	0.50	7.35	6	0.29	10.86	8	0.21	7.72	6	0.26	4.36	4	0.36
Worried about atmosphere	2.82	2	0.24	6.82	6	0.34	8.04	8	0.43	0.97	6	0.99	6.59	4	0.16
Stench and noise due to collection vehicles	2.60	2	0.27	4.23	6	0.65	8.38	8	0.40	3.93	6	0.69	2.91	4	0.57
Traffic accident caused by collection vehicles	7.12	3	0.07	3.22	9	0.96	13.62	12	0.33	13.10	9	0.16	13.44	6	0.04
Aesthetic view	7.39	2	0.03	6.58	6	0.36	7.92	8	0.44	7.74	6	0.26	4.83	4	0.31
Visited any disposal site	1.69	3	0.64	11.04	9	0.27	12.78	12	0.39	10.89	9	0.28	5.35	6	0.50
Distance from residence	0.19	3	0.98	6.62	9	0.68	17.81	12	0.12	12.07	9	0.21	16.80	6	0.01
Treating waste from other areas	2.15	3	0.54	10.53	9	0.31	14.21	12	0.29	7.96	9	0.54	7.36	6	0.29
Special tax	4.47	1	0.04	1.03	3	0.79	8.31	4	0.08	3.50	3	0.32	8.05	2	0.02
Type of waste accepted for disposal	0.33	3	0.96	10.47	9	0.31	19.98	12	0.07	10.38	9	0.32	8.71	6	0.19
Recycle unit along with landfill	4.08	3	0.25	10.61	9	0.30	15.55	12	0.21	20.02	9	0.02	2.97	6	0.81
Eager to participate in planning	2.99	3	0.39	7.85	9	0.55	7.17	12	0.85	10.67	9	0.30	1.86	6	0.93
Most important parameter	3.82	3	0.28	17.66	9	0.04	29.05	12	<0.01	17.42	9	0.04	9.40	6	0.15
Nuisance created due to landfill	5.65	3	0.13	6.78	9	0.66	11.03	12	0.53	4.23	9	0.90	4.71	6	0.58

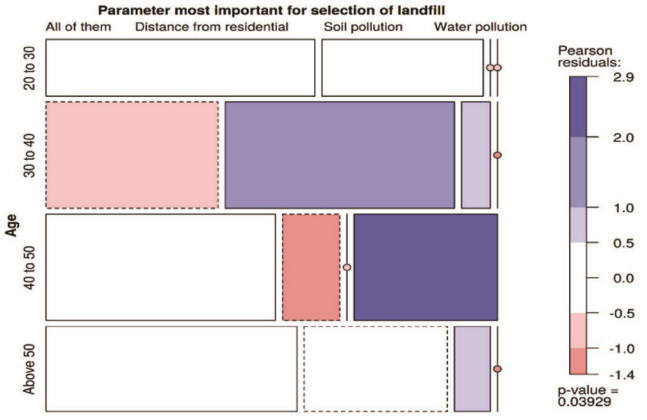

Figure 7. Influence of age-group on the environmental parameters.

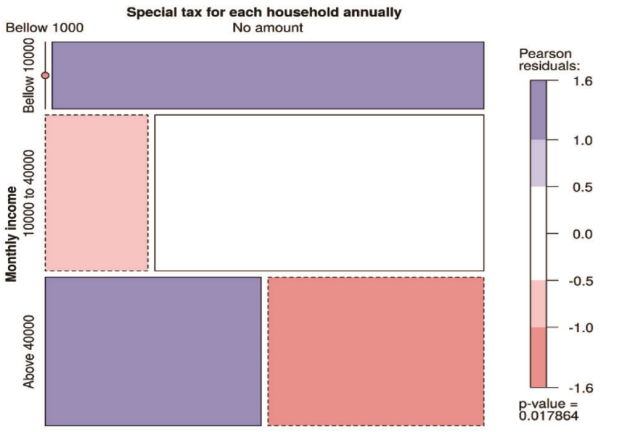

Figure 8. Influence of monthly income on solid waste management tax.

was considered as systematic by the higher-income-group respondents compared to rest of the groups (significant at $P < 0.01$). The awareness level of the respondents related to environmental impacts did not reflect a strong relationship with their education levels, but they supported the facility of landfill with recycle unit (with significance at $P < 0.02$). The age group of the respondents was also found to be an important factor for landfill-related problems [supported by the result of χ^2 test ($P < 0.04$)] and exhibited a negative attitude towards environmental pollution of landfill sites by stressing upon water pollution, soil pollution and distance from the residence. The respondents in the age group 20–30 years and above 50 years were more aware of the environment-related problems and showed their concerns for all the different factors equally (Figure 8).

Conclusion

The present study analysed the public concerns, attitudes and levels of acceptance related to environmentally suitable landfill sites in Dhanbad city. A questionnaire survey was carried out based on the major problems reported in the literature and also prevalent in the study area. This questionnaire comprised basic questions

related to the management issues, impact of a landfill and attitude of people towards the solid waste disposal practices. Awareness among the people (whether they are educated or not) about the problems due to solid waste plays an important role in successful planning of waste management strategy.

The present study will eventually help the policy-makers and concerned authorities to re-evaluate their preferences for landfill sites. A number of socio-economic[22,23] and personal parameters such as the quality and characteristics of the houses[24] and other parameters influenced the awareness of people towards the problems of SWM practices in the study area. These included the age-group, gender, monthly income, education level and occupation of the sample respondents. It has been observed that the present practice of SWM in the city is not at all acceptable by the people. Majority of the people (90%) were dissatisfied with the present SWM system, as the number of community bins was inadequate, the waste was dumped in low-lying areas, and sometimes the waste was found to spill over due to inadequate collection frequency that creates multiple problems such as chocking of drains, foul odour, attraction of vectors and stray animals within the city. The respondents were unaware of the landfill operation, although a few of them visited landfill sites or just had a glance from the outside. The respondents who had visited such a facility were in favour of a new facility. During the survey, the respondents were informed about the harmful impacts of unsanitary landfill or dump sites. As a result, a majority of the respondents (90%) with higher education were in favour of an engineered landfill, but sought assurance from the authorities for scientific management of such landfills. Nuisance due to landfills (flies, rodents, birds and odour) was the major concern of the respondents. It was noticed that people were unwilling to pay tax for SWM, but were ready to participate in the planning for the development of SWM facilities.

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