IMPACT OF POOR SOLID WASTE MANAGEMENT (PSWM) ALONG THE NAJAFGARH DRAIN ON WATER, SANITATION, AND HYGIENE (WASH) STATUS AROUND GURU TEG BAHADUR (GTB) NAGAR

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Abstract

The study from which this article developed assessed how poor solid waste management(PSWM) along the Najafgarh drain affected the WASH situation near GTB Nagar. Mixed research methods were used in the study. Simple random sampling, convenience sampling, and purposive sampling were all used to identify 101 participants. Data was gathered using questionnaires, schedules, and observations before being analysed using IBM SPSS Statistics. Household SWG and residents' ignorance of SWM practices have all contributed to poor open dumping of solid waste along the Najafgarh drain. The study revealed a statistically significant relationship between the solid waste disposal site and the PSWM along the Najafgarh drain, which is associated with outbreaks of WASH-related diseases, with X^2 of 1.172 greater than C^2 of 0.455 and a P-value of 0.01 with X^2 of 33.066 greater than C^2 of 9.21. Municipal authorities should, therefore, provide public sanitation, civic education on SWM techniques, and epidemiology of WASH-related diseases.

Keywords: Poor Solid Waste Management (PSWM), Water, Sanitation and Hygiene (WASH), Solid Waste Generation (SWG), Solid Waste Management (SWM)

Introduction

One of the major environmental issues in Indian cities is solid waste management (SWM). Indian cities face significant environmental challenges as a result of solid waste generation (SWG) and insufficient waste collection, transportation, treatment, and disposal. According to various studies, approximately 90 per cent of solid waste is disposed of unscientifically in open dumps, landfills, and beside or in water bodies, among other places, having an impact on public health and the environment. This problem is exacerbated in most Indian cities by rapid urbanisation and industrialisation. As a result, the majority of current India Waste Management Systems (IWMS) are incapable of dealing with SWG.

Globally, SWG per capita kilogram per capita per day (kg/capita/day) in cities is expected to rise from 1.2 to 1.4 by 2025. Municipal Solid Waste Generation (MSWG) per capita in emerging and recently industrialised countries such as India, is around 0.49 kg/day, which is lower than the 1 to 2.5 kg/day SWG rates in developed countries. However, India currently manages 71.15 million tonnes of Municipal Solid Waste (MSW) per year, despite having a lower solid waste collection and treatment efficiency. As a result, in Indian cities, the lack of safe MSW collection, transportation, and treatment is a serious concern. Untreated waste and poor solid waste management (PSWM) practices endanger public health, and the environment, and contribute to climate change.

Although global waste production is expected to reach 27 billion tonnes per year by 2050, Asia, specifically China and India, will account for one-third of this total. According to Kumar et al. (2017), SWG in India's urban areas will be 0.7 kg per person per day in 2025, which is approximately 4 to 6 times higher than in 1999. By 2011, the amount of SW produced in India's urban areas was approximately 170,000 tonnes per day, which equated to approximately 62 million tonnes of MSW per year. However, due to population growth and changing lifestyles, this is expected to rise by 5 per cent per year. Urban India generated 31.6 million tonnes of waste in 2001 and is currently producing 71.15 million tonnes. Kumar et al. (2017), predicted that by 2041, SWG will have increased fivefold in four decades to 161 million tonnes.

According to a study conducted by Joseph, Rajendiran, Senthilnathan, and Rakesh (2012), unsatisfactory SWM has a direct impact on water sources. Poor solid waste management causes groundwater contamination. Several other studies have thus, been conducted to assess the impact of PSWM on surface water and groundwater but there is little empirical evidence on the impact of PSWM on Water, Sanitation, and Hygiene (WASH), particularly, among urban dwellers. Solid waste produced by city dwellers is thought to be a source of pollution not only in water bodies but also in sanitation and hygiene practices.

The SWG rate varies by Indian state due to factors such as population density, economic status, commercial activity level, culture, and city/region. Kumar et al., (2017), present data on Municipal Solid Waste Generation (MSWG) in various states, indicating high waste generation in Maharashtra (15,364-19,204 tonnes per day), Uttar Pradesh, Tamil Nadu, West Bengal (11,523-15,363 tonnes per day), Andhra Pradesh, Kerala (7,683-11,522 tonnes per day), and Madhya Pradesh, Rajasthan, Gujarat, Karnataka, and Mizoram (3,842-7,662 tonnes per day). However, Jammu and Kashmir, Bihar, Jharkhand, Chhattisgarh, Orissa, Goa, Assam, Arunachal Pradesh, Meghalaya, Tripura, Nagaland, and Manipur have lower SWG (less than 3841 tonnes per day).

Solid waste management is also aided by the domestic economy in Indian cities. According to a review study conducted by Kumar et al. (2017), higher-income groups consume more packaged goods, resulting in higher volumes of plastics, paper, glass, metals, and textiles, among others. The diverse waste composition in Indian cities has most likely jeopardised SWM practices. Various Indian Nagar (townships/suburbs), including Guru Teg Bahadur (GTB), is plagued by garbage and rubbish waste, as well as hazardous SW such as pesticides, paints, used medicine, batteries, and health care wastes such as disposable syringes, sanitary materials, and blood-containing textiles, among others.

Although MSW varies by city, scholars agree that India generates approximately 133,760 tonnes of MSW per day, of which approximately 91,152 tonnes are collectible and approximately 25,884 tonnes are treated. According to Kumar et al. (2017), MSWG per capita in India ranges from approximately 0.17 kg per person per day in small towns like GTB Nagar to approximately 0.62 kg per person per day in large cities like Delhi. Although several studies generalise that PSWM has major negative impacts on public health and the environment in various Indian cities, specific and precise studies to help substantiate the impact of PSWM on WASH status, particularly, in various Nagar (townships/suburbs), are not frequently carried out.

India, particularly, GTB Nagar in Delhi's North West region, is seeing fast urbanisation and population increase. Because of this predicament, enormous amounts of SWG are being dumped down the Najafgarh drain. Thus, it is possible that poor sanitation, hygiene, and insufficient quantity and quality of water resulted. However, there is no empirical data to back up this notion. As a result, the goal of this study was to assess the impact of PSWM on WASH status along the Najafgarh drain near GTB Nagar. The study was conducted along the Najafgarh drain near GTB Nagar because the drain is thought to have been greatly impacted by poor solid waste disposal from city dwellers. It is also assumed that poor solid waste disposal will have a direct impact on the people's WASH in this area. However, there is no scientific evidence to back up this assertion. As a result, this study was required.

Aims and Objectives

The primary goal of the study was to assess the impact of PSWM along the Najafgarh drain on the WASH status near GTB Nagar.

Specific Objectives

(i) To identify various sources of SWG along the Najafgarh drain.

(ii) To assess the impact of PSWM on WASH status along the Najafgarh drain.

(iii) To investigate local strategies for improving SWM along the Najafgarh drain and WASH in the GTB Nagar area.

Hypotheses

(i) SW disposal is associated with PSWM along the Najafgarh drain, or it is not.

(ii) PSWM along the Najafgarh drain is linked to poor WASH status and outbreaks of WASH-related diseases, or it is not.

Methodology

Research Design

The study employed a mixed research methods approach. As a result, the study used both quantitative and qualitative approaches to investigate and assess the impact of PSWM along the Najafgarh drain on WASH status near GTB Nagar. Through in-depth interviews, open-ended questions on a questionnaire, and observations, the qualitative approach was used to investigate the problem of PSWM along the Najafgarh drain on WASH status. The quantitative approach was used to assess the extent to which PSWM has impacted WASH status through a survey that included closed-ended questions on a questionnaire and schedules.

Sampling

A total of 100 people living near GTB Nagar and along the Najafgarh drain were surveyed. In addition, one (1) health official from GTB Polyclinic was chosen for the study. Simple random sampling, convenience sampling, and purposive sampling strategies were all used in the study.

The participants (in this study, households) of 205 along the Najafgarh drain were allocated identification numbers ranging from 001 to 205 using IBM SPSS Statistics Software Version 21. Following that, IBM SPSS Statistics was used to create a random sample of cases with a sample size of 50 per cent using: the Data View window, the Data Tool tab, and lastly, the Case Selection tab. This resulted in a random selection of 100 households, with each picked case receiving a value of 1 and each unselected case receiving a value of 0.

Convenience sampling was used to select respondents from the 100 households' cases chosen at random. This means that any respondents encountered during the survey administration from the sampled households were eligible to take the survey. GTB Polyclinic was chosen on purpose. This is because this clinic is a public institution and is located along the Najafgarh drain, making it easy to obtain data on WASH diseases.

Data Collection

The study used questionnaires, schedules and observations. A questionnaire had both closed-ended and open-ended questions on the questionnaires. Closed-ended questions were used to collect quantitative data, which was critical for determining the impact of PSWM along the Najafgarh on WASH status. On the other hand, open-ended questions were used to collect qualitative data that was critical for investigating the effects of PSWM on WASH status. The use of a questionnaire was chosen for the respondents for the following reasons: the wide geographic coverage of the study area, minimising the respondents' chances of being embarrassed, respondents having time to consider their responses, and thus, avoiding interviewers' bias towards the study, and open-ended questions allowing respondents to express their views.

A schedule was given to the GTB Polyclinic's health official. This method was chosen to ensure that similar questions attempted by residents along the Najafgarh drain were also posed to the health official, and the necessity to collect statistics on WASH-related cases.

The observation technique was used to assess the current state of solid waste disposal along the Najafgarh drain. Primary survey photographs of solid waste disposal along the Najafgarh drain were taken using this method. The information gathered contributes to a better understanding of the impact of PSWM on WASH status.

Data Analysis

The data collected was processed and analysed quantitatively and qualitatively. Inferential statistics were used to analyse quantitative data using IBM SPSS Statistics Software Version 21. The Chi-Square test for association (contingency) was used in inferential statistics to measure the association between two categorical variables depicted in the first hypothesis at a P-value of 0.50 and the second hypothesis at a P-value of 0.01. Chi-square hypotheses tests were used to generalise the quantitative data from respondents. Themes and patterns in qualitative data were deduced for exploratory and comparative analysis with quantitative data. The maps were created with Quantum Geographical Information System (QGIS) Version 3.16.6, and the others were obtained from the MapsofIndia.com database. Finally, the data has been presented in pie charts, tables, bar graphs, maps, and texts in paragraphs.

Results and Discussion

a) *Tracking SWG Sources Along the Najafgarh Drain*

SWG sources along the Najafgarh drain

According to the study, 99 per cent of GTB respondents along the Najafgarh drain consume a diverse range of SWG-causing foods (Table 1.1). These respondents (99%) confirmed, however, that MSW such as plastics, packaged foods, used clothes, shoes, and metals, among others, are largely attributed to the study area's households and stores.

Table 1.1: SWG By Household Food Items

		Frequency	Per cent	Valid Per cent	Cumulative Per cent
Valid	No	1	1.0	1.0	1.0
	Yes	100	99.0	99.0	100.0
	Total	101	100.0	100.0	

Source: Prepared by Research Scholar

According to 93.07 per cent of respondents, individual households are the main contributors to SWG along the Najafgarh drain, with the rest (a total of 6.93%) attributing it to individual passers-by and stores. Unfortunately, 55.4 per cent of the respondents do not have a dustbin or an open compost pit. Worse, 100 per cent of the respondents admitted not treating or practicing SWM techniques like composting, recycling, reusing, or reducing. This could have contributed to the respondents' open dumping of SW along nearby streets (Plate 1.1).

Plate 1.1: Open Dumping of SW Along the Streets of the Respondents' Residences

Source: Surveyed by Research Scholar

According to Plate 1.1, the generated solid waste may have an impact by clogging the drainage system and resulting in urban floods, especially during the rainy season. Furthermore, it can cause water stagnation within the urban drainage system, creating ideal breeding grounds for mosquitos that transmit dengue fever. In addition to dengue fever, outbreaks of other WASH-related diseases such as dysentery, diarrhoea, and typhoid are possible.

First Hypothesis Testing

To determine whether there is a statistically significant relationship between the solid waste disposal site and the PSWM along the Najafgarh drain, a cross-tabulation was created that displayed, observed and expected counts and residuals (Table 1.2).

Table 1.2: Cross-tabulation of Solid Waste Disposal Site and PSWM Along Najafgarh Drain

			Level of agreement on PSWM along Najafgarh drain		Total
			Agree	Undecided	
SW disposal site	Along Najafgarh drain	Count	80	1	81
		Expected Count	79.4	1.6	81.0
		Residual	.6	-.6	
	Garbage Collector	Count	19	1	20
		Expected Count	19.6	.4	20.0
		Residual	-.6	.6	
Total		Count	99	2	101
		Expected Count	99.0	2.0	101.0

Source: Prepared by Research Scholar

Table 1.3: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.172[a]	1	.279		
Continuity Correction[b]	.035	1	.852		
Likelihood Ratio	.931	1	.335		
Fisher's Exact Test				.358	.358
Linear-by-Linear Association	1.160	1	.281		
N of Valid Cases	101				

a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .40.
b. Computed only for a 2x2 table

Source: Prepared by Research Scholar

Table 1.3 shows that a calculated Chi-square value (X^2) of 1.172 and degrees of freedom of 1, with a P-value of 0.279, is associated with a P-value less than 0.50 but greater than 0.25 in the critical table of values. As a result, a P-value of 0.50 was used with a critical value of 0.455 to accept or reject the null or alternative hypothesis. The null hypothesis was rejected, and the alternative hypothesis was accepted because the X^2 is 1.172 greater than the critical value (C^2) of 0.455 at a P-value of 0.50. This means that the association between solid waste dumping location and PSWM along the Najafgarh drain is statistically significant. This suggests that solid waste disposal along the Najafgarh drain is linked to PSWM.

The alternative hypothesis is further supported by the fact that 80.2 per cent of the respondents said that solid waste is disposed of in the Najafgarh drain (Plate 1.2), while the remaining (19.8%) use private garbage collectors (Table 1.4). This is expected to significantly contribute to the water contamination in the Najafgarh drain.

Table 1.4: Solid Waste Disposal Site

		Frequency	Per cent	Valid Per cent	Cumulative Per cent
Valid	Along Najafgarh drain	81	80.2	80.2	80.2
	Garbage Collector	20	19.8	19.8	100.0
	Total	101	100.0	100.0	

Source: Prepared by Research Scholar

Plate 1.2: Solid Waste Disposal Along the Najafgarh Drain

Source: Surveyed by Research Scholar

Plate 1.2 depicts the extent of PSWM along the Najafgarh drain. This indicates that GTB respondents (100%) along the Najafgarh drain lack a treatment mechanism for solid waste. Instead, most respondents (80.2%) preferred solid waste disposal along the Najafgarh drain. These findings imply that PSWM may have contributed to poor WASH status among GTB respondents along the Najafgarh drain. This could also have contributed to high levels of water pollution in the Najafgarh drain.

The study also found that the existing state of the Najafgarh drain, which has a large concentration of SW along it (Plate 1.2), makes it unsuitable for tourism. Instead of giving recreational opportunities, the drain provides a health risk to those who live near the Najafgarh drain. Its effluents emit foul odour, which has been observed to be improperly and infrequently treated by municipal authorities.

SWM efforts along the Najafgarh drain

The study also discovered that the garbage collected from respondents' homes along the Najafgarh drain is temporarily dumped on a garbage collection site (masonry 3-sided storage enclosures) (Plate 1.3, second image from left), which is unfortunately located along the roadside.

Plate 1.3: A Collection Dustbin and Temporary Solid Waste Collection Site

Source: Surveyed by Research Scholar

Plate 1.3 (third to sixth images from left) shows garbage collectors using a tricycle waste cart to transport SW to a temporary solid waste collection site. Although this is a commendable effort by Delhi municipal authorities such as the Municipal Corporation of Delhi (MCD) to manage solid, delays in further collection of masonry waste result in its accumulation along the road side. This means that, although MCD is tasked with collecting garbage, particularly from public places such as GTB market, a small percentage of respondents (19.8%) hire private garbage collectors, while the rest (80.2%) opt for unsatisfactory SW disposal along the Najafgarh drain. This is due to MCD's inability to reach each and every household of the respondents for SW collecting.

The Current State of SWG Along the Najafgarh Drain

According to McAllister's study (2015, p.10), 'one of the biggest barriers to effective waste-management methods in poor nations is a lack of education and awareness.' This survey also revealed a poor literacy rate (49.5%) of the respondents had completed basic school), which was linked to 100 per cent of respondents having little or no awareness of solid waste treatment along the Najafgarh drain. This implies that respondents are more likely to dispose of their solid waste in an ineffective manner.

Several studies, including those by Nanda and Berruti (2021), have found that consumption patterns among urban dwellers are a significant contributor to MSWG. The current study also discovered that household food items consumed by respondents, whether packed or unpacked, contribute significantly, to MSWG. Kitchen waste, yard waste, paper and cardboard, plastic and rubber, metal, glass, electronic waste, inert materials, and miscellaneous trash are all examples of MSW. However, this comes at the expense of low MSWM participation, as 100 per cent of the respondents expressed a lack of knowledge about solid waste treatment.

According to McAllister (2015, p.10), 'the need to improve public awareness of, and community participation in waste management has been widely recognised by researchers as necessary to create sustainable waste systems and promote environmental citizenship amongst community members.' According to the findings of a Malaysian study conducted by Aini, et al. (2002), as cited in McAllister (2015, p.10), to overcome the solid waste crisis, 'individual conscience needs to be raised through environmental awareness and concern, inculcation of sustainable consumption practices, and waste management education.' This is thought to have altered consumption patterns and increased awareness of SWG and SWM among city dwellers. This can also be applied to and replicated for respondents who live along the Najafgarh drain in the GTB Nagar area. As a result, sanitation sensitisation campaigns, hygiene promotion, and education are critical pillars for achieving SWM among city dwellers, including those who live along the Najafgarh drain in the GTB Nagar area.

First Hypothesis Testing and SWM Efforts Along the Najafgarh Drain

The study by Hazra and Goel (2009) established different collection methods used in Kolkata Municipal Corporation (KMC), which include house-to-house collection (primary collection) by handcart and tricycle, and collection from roadside storage areas (masonry 3-sided storage enclosures). This study also discovered that such collection strategies are currently in use in the study area, albeit infrequently. However, Hazra and Goel (2009) discovered that all uncollected solid waste is disposed of on vacant land and in canals. The same situation was observed where the Najafgarh drain is gradually being transformed into a SW dumping site in the GTB Nagar neighbourhood.

A review study by Gupta, Yadav and Kumar (2015) also established that waste collection in India is very unorganised. Their research revealed that most urban areas lack MSW storage at the source, as well as poorly designed, located and maintained collection bins, resulting in poor collection efficiency. Thus, if collection bins are available, they are commonly used for both decomposable and non-decomposable waste (no waste segregation is performed), and the waste is disposed of at a communal disposal centre or even at water bodies present in urban areas. According to Sexena et al. (2010), Rathi (2006), Siddiqui et al. (2006), Gupta et al. (1998), Maudgal (1995), and Khan (1994), as cited in Gupta, Yadav, and Kumar (2015), the average collection efficiency for MSW in Indian cities and states was around 70 per cent, resulting in PSWM. Similarly, the current study discovered that the most convenient solid waste disposal site is along the Najafgarh drain. This could have resulted in PSWM along the Najafgarh drain. As a result, statistical hypothesis testing data shows a significant relationship between the solid waste disposal site and the PSWM along the Najafgarh drain. The data then indicates that PSWM along the Najafgarh drain is directly related and attributed to poor solid waste disposal among GTB Nagar respondents.

b) *The Impact of PSWM Along the Najafgarh Drain on WASH Status*

The Impact of PSWM on WASH Status

Respondents suggested that PSWM along the Najafgarh drain had a significant impact on water contamination, which resulted in a foul odour emanating from the drain. As a result, respondents claimed that the drain is highly polluted. Consequently, the water quality of the Najafgarh drain may have been contaminated. However, scientific research is required to determine the water quality of the Najafgarh drain.

Respondents also stated that unmanaged and uncollected solid waste disposal obstructs the flow of water in the drain, causing it to stagnate. Stagnant water becomes a breeding ground for mosquitos, which can lead to water-borne diseases. As a result, the Najafgarh drain may endanger human health. Respondents also stated that solid waste is a serious threat because it ferments, promoting the survival and growth of microbial pathogens.

Furthermore, it was discovered that dumping untreated solid waste directly into or along the Najafgarh drain not only causes flash floods but also accumulates hazardous compounds in the food chain for aquatic plants and animals that feed on it. This could result in a loss of wildlife along the Najafgarh drain. Additionally, due to claimed water contamination and biodiversity loss, the drain is unable to support the tourism business.

Second Hypothesis Testing

This hypothesis was divided into two parts to allow for a clear statistical analysis of the impact of PSWM on WASH status and then the impact of PSWM on the outbreak of WASH-related diseases.

Table 1.5: Cross-tabulation of PSWM Along Najafgarh Drain and its Impact on WASH Status

			Impact of PSWM on WASH Status			Total
			Agree	Undecided	Disagree	
Level of agreement on PSWM along Najafgarh drain	Agree	Count	93	4	2	99
		Expected Count	92.1	4.9	2.0	99.0
	Undecided	Count	1	1	0	2
		Expected Count	1.9	.1	.0	2.0
Total		Count	94	5	2	101
		Expected Count	94.0	5.0	2.0	101.0

Source: Prepared by Research Scholar

Table 1.6: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.812[a]	2	.012
Likelihood Ratio	3.568	2	.168
Linear-by-Linear Association	2.824	1	.093
N of Valid Cases	101		

a. 5 cells (83.3%) have expected count less than 5. The minimum expected count is .04.

Source: Prepared by Research Scholar

The Chi-square test significance level (P-value) is 0.012 less than the tabulated P-value of 0.01 with a critical value of 9.21 at 2 degrees of freedom. Because the X^2 of 8.812 is less than the C^2 of 9.21 at a P-value of 0.01 with 2 degrees of freedom, the null hypothesis was accepted, and the alternative hypothesis was rejected. This implies that there is no statistically significant link between PSWM along the Najafgarh drain and the poor WASH status of the respondent's residence. As a result, any poor WASH status among respondents' dwellers along the Najafgarh drain is entirely due to chance or other effluents that might be responsible other than solid waste alone. This also implies that PSWM may not have had a significant impact on the water in the Najafgarh drain, as well as sanitation and hygiene practices. More research is needed to understand the impact of solid waste disposal on water quality in the Najafgarh drain.

The other hypothesis derived from the second hypothesis proposed that PSWM along the Najafgarh drain is associated with outbreaks of WASH-related diseases, or that it is not.

Table 1.7: Cross-tabulation on the Impact of PSWM on the Outbreak of WASH Related Diseases

			Level of agreement of PSWM along Najafgarh on outbreak of WASH related diseases		Total
			Agree	Disagree	
Impact of PSWM on outbreak of WASH related diseases	Agree	Count	93	2	95
		Expected Count	92.2	2.8	95.0
	Undecided	Count	5	0	5
		Expected Count	4.9	.1	5.0
	Disagree	Count	0	1	1
		Expected Count	1.0	.0	1.0
Total		Count	98	3	101
		Expected Count	98.0	3.0	101.0

Source: Prepared by Research Scholar

Table 1.8: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	33.066[a]	2	.000
Likelihood Ratio	7.609	2	.022
Linear-by-Linear Association	12.957	1	.000
N of Valid Cases	101		

a. 5 cells (83.3%) have expected count less than 5. The minimum expected count is .03.

Source: Prepared by Research Scholar

The Chi-square test significance level (P-value) is 0.000 less than the tabulated P-value of 0.01 at 2 degrees of freedom, with a critical value of 9.21. However, because the X^2 of 33.066 exceeds the C^2 of 9.21 at a P-value of 0.01 with 2 degrees of freedom, the alternative hypothesis is accepted, and the null hypothesis is rejected. This implies that there is a statistically significant association between PSWM along the Najafgarh drain and outbreaks of WASH-related diseases. This also implies that, despite the lack of data from the GTB Polyclinic on WASH-related diseases, respondents' claims about the availability of WASH-related diseases due to PSWM along the Najafgarh drain may be correct. As a result, the likelihood of PSWM along the Najafgarh drain being linked or associated with an outbreak of WASH-related diseases in the vicinity of GTB Nagar is high.

The State of WASH-related Diseases

Respondents agreed that dengue fever, dysentery, and diarrhoea are common WASH-related diseases in their Najafgarh drain neighbourhood. This could be attributed to a lack of sanitary and hygiene practices. Srivastava, et al. (2015), discovered that PSWM can cause outbreaks of WASH-related diseases. Similarly, the current study has discovered a possible link between a solid waste disposal site and PSWM along the Najafgarh drain, which could lead to WASH-related diseases. However, health officials at GTB Polyclinic failed to provide statistical data on WASH-related disease cases reported from 2017 to 2021. Despite being a government hospital, this occurred due to poor record-keeping of statistical data on WASH-related diseases. Although the study found a statistically significant link between PSWM along the Najafgarh drain and the outbreak of WASH-related diseases, the availability of GTB Polyclinic data would have substantiated the claim about individual respondents' availability of WASH-related diseases. As a result, additional research is needed to track the status of WASH-related diseases along the Najafgarh drain.

c) *Strategies to Improve SWM Along the Najafgarh Drain and the Wash Status*

MCD and NDMC's Roles in the Research Area

Although the MCD and the New Delhi Municipal Committee (NDMC) are the two major bodies in charge of MSWM in Delhi, respondents were dissatisfied with these MSWM authorities. The respondents expressed dissatisfaction with MCD and NDMC's assistance with SWM techniques along the Najafgarh drain. However, these findings contradict the researchers' own observations of garbage collectors (Plate 1.3) transporting solid waste to masonry. These garbage collectors could have been used by MCD and NDMC. More research, however, is required to estimate the number of garbage collectors and identify their employers.

Local Strategies to Improve SWM and WASH Along the Najafgarh Drain

Composting, controlled tipping/burying, incineration, and sanitary landfills are some of the simple and practical methods of SWM, treatment/reuse, and disposal that have been proposed.

Composting

Respondents suggested that composting could be one method of reducing waste and thus improving WASH status. A biological waste treatment process is used in this mechanism. According to Srivastava, et al. (2015), it involves microorganisms breaking down complex organic compounds into simpler ones. Municipal Solid Waste composting is one of the most promising and cost-effective MSWM options. The Government of India (GOI) encouraged this method in the early 1960s, but it was blocked in the 4th, five-year plan (1969–1974), much to the chagrin of many waste managers. However, in 1974, the Government of India launched a modified scheme to reintroduce MSW composting, particularly in cities with populations greater than 0.3 million, including Delhi NCT.

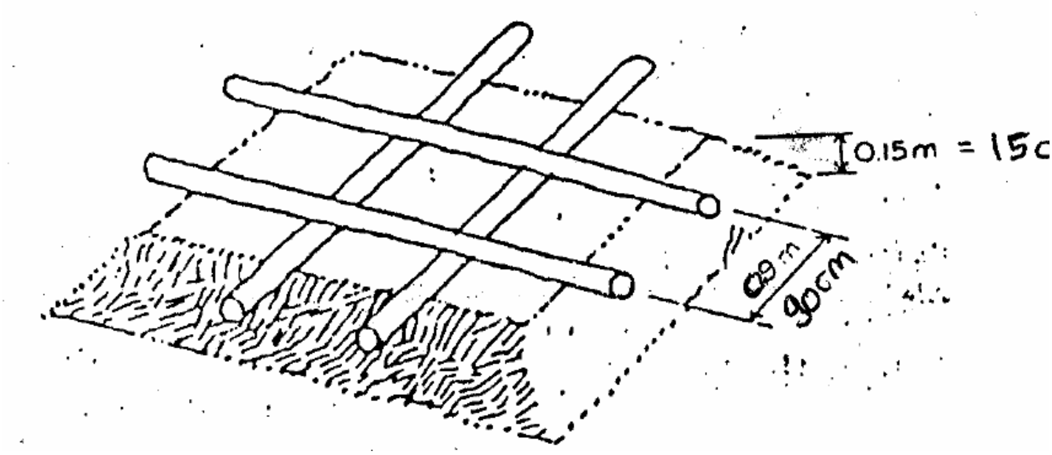
Municipal Solid Waste composting occurs on a large scale as well as at a decentralised level in India. Unfortunately, little effort is visible at the local level, such as in the current study area. Although composting is not considered a final disposal method, it is the best way to convert waste into a useful product at the local level, thereby contributing to an improvement in WASH status. Alemayehu (2004) proposed certain composting steps. Similar steps were observed and can be replicated in the current research area.

Composting Process

Some of the suggested steps for the composting process are as follows:

1. Sort and/or separate the compostable organic matter, such as garbage, grass, and dung, from the non-compostable organic matter, such as plastic, leather, ceramic, clay, or steel items that clog the decomposition process.
2. Combine all wastes in the same proportions, such as animal manure, kitchen waste, weeds, and house sweepings. It is critical to include and combine human and animal waste to decorate and facilitate the biodegradation process. Including those waste topics not only supplements the decomposition method, but it also enriches the waste in nitrogen and phosphorous, which are important factors for plant growth. However, the use of human or animal waste necessitates precautions because it may contaminate crops as well as the hands and toes of farm workers. This may also result in continuous transmission of communicable diseases, outweighing the benefit of waste reuse.
3. Compost sites can be created by excavating a shallow hole, the size of which can vary depending on the amount of trash to be composted, or the waste can be placed above the ground. Placing it above the floor makes it easier to work with the waste inside the composting procedure.
4. Pile the looked after and combined SW on the floor to a height of about 0.15 metres (15 centimetres). Place four spherical sticks horizontally on the pile's pinnacle (Plate 1.4). The space between the poles will be 75 centimetres (cm) to 90 centimetres (cm).

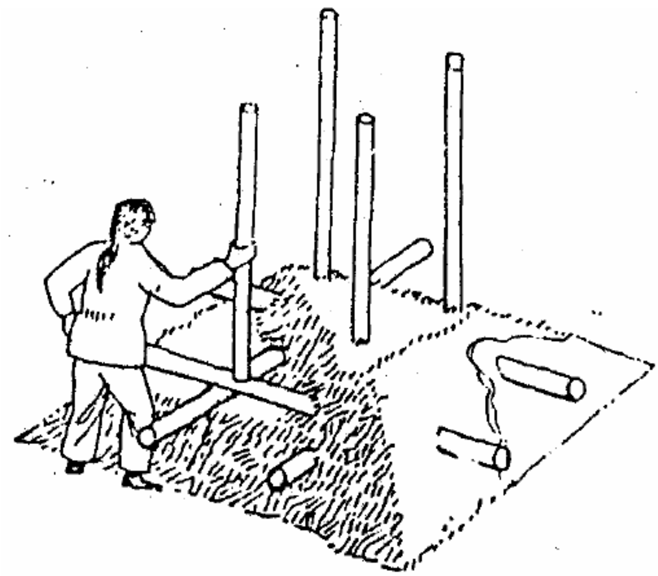
Plate 1.4: Piling the First Layer of Organic Waste Matter



Source: Alemayehu (2004, p.16)

5. Insert four vertical poles into the nook of the horizontally laid wood poles (Plate 1.5).

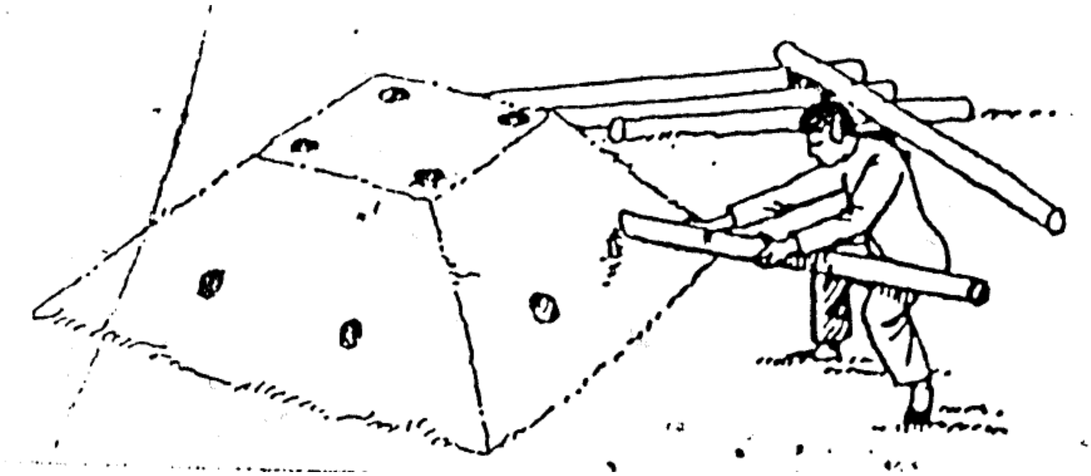
Plate 1.5: Vertical Poles in the Pile



Source: Alemayehu (2004, p.16)

6. Extend the length of the sorted-out waste rely on the pinnacle of the wood poles by 90cm.
7. Cover the completed waste pile with 50cm of earth and animal manure (if available), and remove the poles from the pile (Plate 1.6).

Plate 1.6: Final Covering and Tracking out the Poles from the Pile



Source: Alemayehu (2004, p.17)

Although composting was found to be the most convenient method for MSWM, a study by Annepu (2012), as cited in Gupta, Yadav, and Kumar (2015), discovered that only 6–7% of MSW in India was converted into compost. Nonetheless, Alemayehu (2004) concludes that the soil/manure cover will aid in keeping rainwater out of the pile. It reduces evaporation, nitrogen (nutrient) loss, and fly breeding, among other benefits. The holes made by the poles will help oxygen enter the pile, resulting in an aerobic composting process. This method produces dark-looking compost and stable humus, as well as no nuisance or odour.

Controlled Tipping/Burying

Solid waste that has not been recycled or used should be discarded. The disposal can be accomplished in a variety of ways. The most important method, however, is one that can permanently isolate the waste. Tipping is one way to accomplish this. According to Alemayehu (2004), tipping entails isolating any type of waste without bothering to sort or separate it. As a result, controlled tipping is a simple, effective, and relatively inexpensive method of waste disposal.

The Process of Controlled Tipping

According to Alemayehu (2004), this method entails digging a hole in the ground with a depth of 1-2 meters and width, and length of 60 centimeters for a household. The method, on the other hand, can be used as a one-time or daily operation. It is preferable if it is done on a daily basis. The following are some of the steps it proposes:

1. A disposal site is identified within any residential, commercial, or institutional compound. However, the location should not be near any water sources, houses, or kitchens, as well as a road or path.
2. Store the dugout earth near the pit for later use.
3. Dump the generated SW (garbage, refuse, etc.) into the pit on a daily basis (Plate 1.7)

Source: Alemayehu (2004, p. 20)

4. Everyday, cover the waste with excavated soil.

In short, this method entails dumping solid waste generated every day into a pit and covering it with earth to prevent flies and vermin from accessing it. The process is repeated until the pit is filled, at which point it should be completely covered with earth and a new one dug next to the old one. Flies, mosquitoes, rodents, birds, and other nuisance animals will not be able to breed or feed using this method. In addition, Alemayehu (2004) demonstrated that decomposable waste will continue to condition the soil. Crops grown on completed sites grow faster, and the immediate vicinity of the dwelling house is always clean.

Incineration

Although incineration is costly, it requires skilled personnel, and contributes to air pollution, WHO (2002) recommended that incineration is a high temperature dry condition process that converts organic and combustible waste to inorganic and incombustible matter, resulting in a significant reduction in waste volume and weight. This method, however, is selective in that pressurised gas containers; large amounts of reactive chemical waste; silver salt and photographic or radiographic waste;

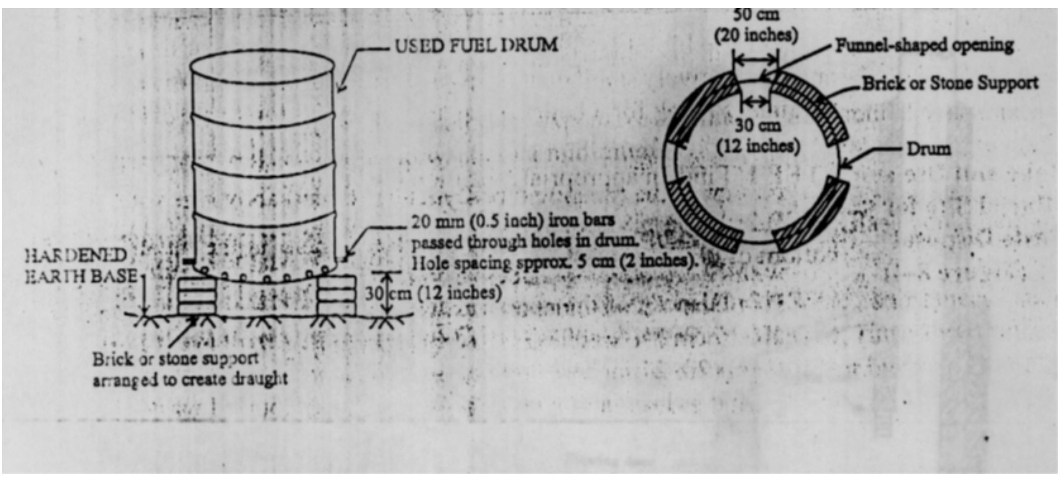
halogenated plastics, such as polyvinyl chloride (PVC); waste containing mercury or cadmium, such as broken thermometers; used batteries and lead-lined wooden panels; and sealed ampoules or ampoules containing heavy metals cannot be incinerated. Nonetheless, the method is cost-effective because incinerators can be located near the source of waste. This is likely to reduce municipal transportation costs to various landfill sites. In general, incinerated solid waste has a content of combustible matter that is 60 per cent higher than the content of non-combustible solids that is 5 per cent lower. Furthermore, the content of non-combustible fines should be less than 20 per cent, and the moisture content should be less than 30 per cent. However, Gupta, Yadav, and Kumar (2015) discovered that incineration and bio-methanation types of waste-to-energy of solid waste disposal were introduced in India but contribute only marginally. Thus, municipal authorities in the study area must promote these methods if solid waste disposal is to be managed thoroughly, which can ultimately result in improved WASH status and prevent outbreak of WASH-related diseases.

Drum Incinerator

Despite being an expensive method, incinerators are used to remove microorganisms from waste and reduce solid waste to ashes. Prajapati et al. (2021), recommended that in local residence areas, such as along the Najafgarh drain, SW be incinerated using a drum incinerator rather than high-temperature incinerators, which are usually out of reach of the local community. The local community can build and use a simple drum incinerator for SW disposal by following the steps outlined below:

1. Choose a downwind location whenever possible.
2. Construct a simple incinerator out of local materials (such as mud or stone) or old oil. drum (e.g., 80-100 litres drum). The size is determined by the amount of waste collected on a daily basis (Plate 1.8).

Plate 1.8: Design for a Simple Oil Drum Incinerator



Source: Alemayehu (2004, p.23)

3. Check that the incinerator has:
   (i) Enough air inlets beneath for proper combustion;
   (ii) Place fire bars loosely to allow for expansion;
   (iii) A large enough opening to allow for the addition of new refuse and the removal of ashes; and
   (iv) A long enough chimney to allow for a good draught and smoke evacuation.
4. Set the drum on hardened earth or a concrete foundation.
5. Combustible waste, such as paper and cardboard, as well as used dressings and other contaminated solid wastes, should be burned. If the solid waste or refuse is wet, add Kerosene to create a hot fire that will burn through all of the waste. The ash produced by incineration can be treated as non-contaminated waste.

Sanitary Landfill

Sanitary landfill is another option. According to Pattrnaik and Reddy (2010), sanitary landfilling is the practice of disposing of waste on land without causing nuisances or endangering public health or safety. Although sanitary landfill requires more land and equipment to implement, it is distinct from open dumps. Sanitary landfills are distinguished by the following characteristics:

1. The waste is disposed of in a prescribed manner.
2. Waste materials are spread out and compacted using heavy machinery.
3. Each day, a layer of compacted soil is applied to the waste.

Although sanitary landfills may not be appropriate for respondents' dwellers along the Najafgarh drain due to the highly skilled professionals required for proper operation, planning, regulating and controlling, and deposition of solid waste on selected areas, MCD and NDMC are advised to identify more sanitary landfills in order to accommodate the massive solid waste generated not only along the Najafgarh drain but throughout the city of Delhi NCT. Sanitary landfills are an excellent option for permanent disposal and wastelands (hills, valleys) become useful (e.g., flat ground for recreation).

Conclusions

The study was carried out to assess the impact of PSWM along the Najafgarh drain on the WASH situation in the vicinity of GTB Nagar. The study participants included 100 people living along the Najafgarh drain near GTB Nagar, as well as one health official from the GTB Polyclinic. Households and respondents were chosen using simple random sampling and convenience sampling, respectively. To select the health official, purposive sampling was used. Data was gathered through questionnaires and observations before being statistically analysed using Pearson's Chi-square of association and IBM SPSS Statistics Software Version 21. Maps were also created using QGIS Version 3.16.6.

According to the findings, households are the primary source of SWG along the Najafgarh drain (93.07% of the respondents agreed to this fact). Uncontrolled SWG is occurring at a faster rate in this study area, while respondents (100%) have little or no knowledge of SW treatment and management practices. Furthermore, lack of access to a dustbin or open compost pit (55.4% of respondents have no dustbin or open compost pit) for temporary SW storage has resulted in poor open dumping of SW, particularly along the Najafgarh drain, as attested by 80.2 per cent of the respondents. The study also found a statistically significant relationship between the SW disposal site and the PSWM along the Najafgarh drain.

Although sampled respondents agree that PSWM along the Najafgarh drain may have contaminated the water in the drain, as well as poor sanitation and hygiene practices, little effort is being made to temporarily manage SW through masonry-3-sided storage enclosures. Thus, at a P-value of 0.50, the calculated Chi-square (X^2) of 1.172 was greater than the critical value (C^2) of 0.455. Statistically, this resulted in the acceptance of the alternative hypothesis that there is a significant relationship between the SW dumping location and the PSWM along the Najafgarh drain. However, at a P-value of 0.01, the calculated X^2 of 8.812 for the second hypothesis was less than the C^2 of 9.21. Statistically, this resulted in the acceptance of the null hypothesis, which states that there is no significant link between PSWM along the Najafgarh drain and poor WASH status in the GTB Nagar area. This implies that any poor WASH status among the residents is due to chances alone. However, at a P-value of 0.01, the calculated X^2 of 33.066 for the last hypothesis was greater than the C^2 of 9.21. According to statistics, PSWM along the Najafgarh drain is significantly associated with the outbreak of WASH-related diseases. These findings indicate that, in addition to PSWM along the Najafgarh drain, other factors such as a lack of SW treatment have an impact on WASH status along the Najafgarh drain. Furthermore, the lack of SW treatment and its open dumping within the residence and along the Najafgarh drain may have both short- and long-term consequences on the outbreak of WASH-related diseases. Although there is a lack of data from GTB Polyclinic on WASH-related disease cases, this study's Chi-square tests revealed that PSWM along the Najafgarh drain is significantly associated with the outbreak of WASH-related diseases.

Overall, the SW disposal techniques used by the sampled respondents resulted in PSWM along the Najafgarh drain. Poor Solid Waste Management along the Najafgarh drain, on the other hand, is not directly related to poor WASH status. Other indirect factors, such as open dumping of SW along the Najafgarh drain and a lack of SW treatment (collectively poor WASH status), have been statistically linked to outbreaks of WASH-related diseases. In general, the study recommends that municipal authorities provide civic education on SW treatment and encourage the use of local SWM strategies. The residence should also have public sanitary facilities. This has the potential of having a greater impact on preventing the spread of WASH-related diseases.

Recommendations

Based on the study's findings, this article recommends that the following be considered and implemented among the respondents along the Najafgarh drain around GTB Nagar to improve both SWM and WASH status:

1. SWM techniques and practices must be civically educated among respondents;
2. For proper SWM, respondents should be encouraged to use local strategies such as composting, controlled tipping/burying, incineration, and sanitary landfill;
3. Respondents must be civically educated about the link between PSWM and the outbreak of WASH-related diseases;
4. Municipal authorities should provide public sanitation facilities in the respondents' neighborhoods and educate them on how to use it;
5. Respondents should be warned not to drink or use water from the Najafgarh drain in any way because its water quality has not been thoroughly assessed;
6. Respondents should be educated on the epidemiology of WASH-related diseases like dengue fever; and
7. There is a need to improve and keep WASH-related disease data up to date.

References

Alemayehu, E. (2004). Solid and Liquid Waste Management for Extension Health Workers. *Jimma University in Collaboration with the Ethiopia Public Health Training Initiative, The Carter Centre, the Ethiopia Ministry of Health, and the Ethiopia Ministry of Education*. Accessed at: https://www.cartercenter.org/resources/pdfs/health/ephti/library/lecture_notes/health_extension_trainees/ln_hew_solid_waste_final.pdf.

Gupta, N., Yadav, K.K., and Kumar, V. (2015). 'A Review on Current Status of Municipal Solid Waste Management in India.' *Journal of Environmental Sciences*, *37*, 206-217. Accessed at: https://www.sciencedirect.com/science/article/pii/S1001074215002995.

Hazra, T., and Goel, S. (2009). 'Solid Waste Management in Kolkata, India: Practices and Challenges.' *Waste Management*, *29*(1), 470-478. Accessed at:https://reader.elsevier.com/reader/sd/pii/S0956053X08000901?token=490F4E3D764C23E5647BCBD85CDABF3566C01F8BCA1EAAEA0BE8F84668446D5E747D3020F6CA9FCC318C6A1C071EC8D6&originRegion=eu-west-1&o-riginCreation=20220103161700.

Hoornweg, D., and Bhada-Tata, P. (2012). *What a Waste: A Global Review of Solid Waste Management*. Accessed at: https://openknowledge.worldbank.org/bitstream/handle/10986/17388/68135.pdf?sequence=8&isAllowed=y.

Joseph, K., Rajendiran, S., Senthilnathan, R., and Rakesh, M. (2012). 'Integrated Approach to Solid Waste Management in Chennai: An Indian Metro City.' *Journal of Material Cycles and Waste Management*, *14*(2), 75-84. Accessed at: https://link.springer.com/article/10.1007/s10163-012-0046-0.

Kumar, S., Smith, S.R., Fowler, G., Velis, C., Kumar, S.J., Arya, S., and Cheeseman, C. (2017). 'Challenges and Opportunities Associated with Waste Management in India.' *Royal Society Open Science*, *4*(3), 160764. Accessed at: https://royalsocietypublishing.org/doi/pdf/10.1098/rsos.160764.

McAllister, J. (2015). Factors Influencing Solid-waste Management in the Developing World. Accessed at: https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1537&context=gradreports.

Nanda, S., and Berruti, F. (2021). Municipal Solid Waste Management and Landfilling Technologies: A Review. *Environmental Chemistry Letters*, *19*(2), 1433-1456. Accessed at: https://link.springer.com/content/pdf/10.1007/s10311-020-01100-y.pdf.

Pattnaik, S., and Reddy, M.V. (2010). Assessment of Municipal Solid Waste Management in Puducherry (Pondicherry), India. *Resources, Conservation and Recycling*, *54*(8), 512-520. Accessed at: https://www.sciencedirect.com/science/article/pii/S0921344909002328.

Prajapati, K.K., Yadav, M., Singh, R.M., Parikh, P., Pareek, N., and Vivekanand, V. (2021). 'An Overview of Municipal Solid Waste Management in Jaipur City, India-Current Status, Challenges and Recommendations.' *Renewable and Sustainable Energy Reviews*, *152*, 111703. Accessed at: https://reader.elsevier.com/reader/sd/pii/S1364032121009771?token=2FC5D739A7156723A44F7A4EF158CC60AF9AB9507FA89B5AC28FA65BCB0E463E8D2CF706FD7E6EF867CBA1D7E61D9B1F&originRegion=eu-west-1&originCreation=20220103153531.

Srivastava, V., Ismail, S.A., Singh, P., and Singh, R.P. (2015). 'Urban Solid Waste Management in the Developing World with Emphasis on India: Challenges and Opportunities.' *Reviews in Environmental Science and Bio/Technology*, *14*(2), 317-337. Accessed at: https://link.springer.com/content/pdf/10.1007/s11157-014-9352-4.pdf.

Vasanthi, P., Kaliappan, S., and Srinivasaraghavan, R. (2008). Impact of Poor Solid Waste Management on Groundwater. *Environmental Monitoring and Assessment*, *143*(1), 227-238. Accessed at: https://link.springer.com/content/pdf/10.1007/s10661-007-9971-0.pdf.

WHO (2002). Part II. Technical Aspects: 8. Sanitation: 8.5 Management of Refuse: 8.5.6 Medical Wastes. Environmental Health in Emergencies and Disasters: A Practical Guide. *WHO Health Library for Disasters*. Accessed at: http://www.nzdl.org/cgi-bin/library?e=d-00000-00---off-0helid--00-0----0-10-0---0---0direct-10---4-------0-1l--11-en-50---20-about---00-0-1-00-0--4----0-0-11-10-0utfZz-8-00&a=d&cl=CL1.1&d=HASH01c97ac5f84b6ff13edee4e0.6.3.5.7.