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Qualitative Evaluation of the Ground Water in Residential Areas Around Solid Waste Dumpsites in Kanpur City

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Abstract

Groundwater is a vital and purest form of natural resource. In recent years, various anthropogenic causes have threatened its natural quality. Therefore, its suitability for drinking, irrigation, and other purposes creates doubtful conditions for human well-being, especially in developing countries. This present study evaluated groundwater quality for drinking, and human health hazard purposes, particularly in residential areas around municipal solid waste dumpsites in Kanpur city. This is a qualitative analysis based on the questionnaire survey method. The findings of this survey help qualitative evaluation of the quality of underground water on which the whole population depends for their daily needs.

Keywords: Groundwater Quality, municipal solid waste Dumpsites, Public Health

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Introduction

Water on the surface and underground is a critical natural resource essential for sustaining life on Earth and supporting the sustainable development of key socioeconomic sectors such as agriculture, industry, and urbanization. Urban groundwater, in particular, has emerged as one of the most pressing global challenges (Tellam *et al.*, 2006). The quality of groundwater is increasingly compromised by both natural (geogenic) and human-induced (anthropogenic) activities (Schwarzenbach *et al.*, 2010; Jain, 2012). In India, groundwater is extensively utilized for drinking, irrigation, and industrial purposes. However, various human activities related to land and water management significantly pollute these vital resources. Contaminants such as fluoride, iron, salinity, nitrate, and arsenic are often linked to natural mineralization processes (Dahariya, 2016). While anthropogenic activities are a well-known cause of groundwater pollution, natural processes also contribute to the mobilization of pollutants. Organic pollutants from improperly managed industrial, municipal, and agricultural waste further degrade groundwater quality. Inefficient waste handling, storage, and disposal practices of liquid, solid, and semi-solid waste exacerbate organic and microbial contamination. In India, 80–90% of municipal waste is dumped in unscientifically managed landfills (Ahluwalia and Patel, 2018), leading to percolation and groundwater pollution. Heavy metals such as fluoride, arsenic, cadmium, iron, mercury, and other toxic substances, whether of natural origin or from residential, industrial, and agricultural sources, frequently exceed permissible limits in drinking water (Ololade *et al.*, 2009). This has severe consequences, with over 60 million people in India suffering from fluorosis due to fluoride-contaminated water (Raju *et al.*, 2009). Water pollution not only deteriorates groundwater quality but also poses substantial risks to public health, economic progress, and social well-being (Milovanovic, 2007).

In Kanpur, the management of municipal solid waste (MSW) is overseen by two primary agencies: A2Z Infrastructure Private Ltd. and Kanpur Nagar Nigam (KNM). These agencies are responsible for the collection, transportation, and disposal of the city's solid waste. The city's average waste generation is approximately 1,500 tons per day. According to municipal records, all MSW generated is transported to the Panki open dump site, the sole active dumping site in Kanpur. This site, which covers an area of 4.6 km², has been in use since 2010 and receives around 70% of the waste collected from domestic households, industrial activities, and other sources (Fig. 1).

Fig.1: Municipal Dumping Site at Panki Site 3, Kanpur

Literature Review

Groundwater quality has been a significant focus of research, particularly in areas surrounding municipal solid waste (MSW) dumping sites. Several studies have examined this issue in various locations. Gautam *et al.* (2011) evaluated groundwater quality near the MSW dumping site in Sewapura, Jaipur, while Adeolu *et al.* (2011) investigated groundwater contamination from leachate near a landfill. Bhalla *et al.* (2012) assessed groundwater quality near MSW landfills using the Aggregate Index Method. Shenbagarani

(2013) analyzed groundwater quality in residential areas close to dumping sites. Kamboj and Choudhary (2013) explored the impact of solid waste disposal on groundwater quality at the Gazipur dumping site in Delhi. Prasanna and Annadurai (2016) studied groundwater quality in and around the Perungudi dumping site in Chennai, and Kaushal and Sharma (2016) examined methane emissions from the Panki open dump site in Kanpur, India. Further, Sankhla *et al.* (2018) highlighted arsenic contamination in water and its toxic effects on human health. Chilukuri *et al.* (2019) assessed groundwater quality near a municipal dump site in Guntur District, Andhra Pradesh, India, while Singh (2019) reviewed groundwater pollution, its causes, assessment methods, and mitigation strategies. Munagala *et al.* (2020) calculated the water quality index for groundwater near the Guntur municipal dump site. Tripathi and Dwivedi (2021) examined the impact of dumping on groundwater quality, and Rajput *et al.* (2021) analyzed groundwater contamination from MSW dumping in Nashik, emphasizing remediation through energy recovery. Chaudhary *et al.* (2022) investigated groundwater and soil quality near a municipal waste disposal site in Silchar, Assam. More recently, Varne *et al.* (2023) studied groundwater contamination around the Pathardi landfill in Nashik, Maharashtra, while Abdel-Shafy *et al.* (2024) provided an in-depth discussion on landfill leachate sources, composition, and treatment methods.

In this context, we conducted a survey in residential areas around the Kanpur dumping site to assess groundwater quality and its impact on the local population.

Questionnaire Design

In our study, we designed a questionnaire comprising 13 questions organized into four sections: Demographic Information, General Perception, Groundwater Quality Assessment, and Perceived Impact. The survey includes a mix of question types, such as open-ended questions, closed-ended multiple-choice questions, Likert scale questions, rating scale questions, and yes/no questions, covering a range of relevant topics.

Participant Recruitment and Questionnaire Administration

The participants were recruited for the study by simple random sampling in particular areas. In our case, the target population is residents of all age groups, genders and occupations around municipal waste dumping sites. The questionnaire was administered online and emailed to the residents who agreed to participate in the study. The written questionnaire was provided to the residents who could not access email.

Result and Discussion

In our case, the survey response rate was more than 80%. The response rate can be calculated by dividing the number of completed survey responses by the number of people who viewed or started the survey. The survey was administered online and offline to 3,00 residents, out of which 250 were completed, resulting in a response rate of 83.3%. For demographic information, we collected data on the age, gender, and occupation of respondents (Fig. 2, 3 & 4). 50% of respondents are in the 20-40 age group, as this age group is the most active and technologically active. 80% of respondents are males in this survey, while the occupation category has almost equal distribution in the government, private, business, and student categories.

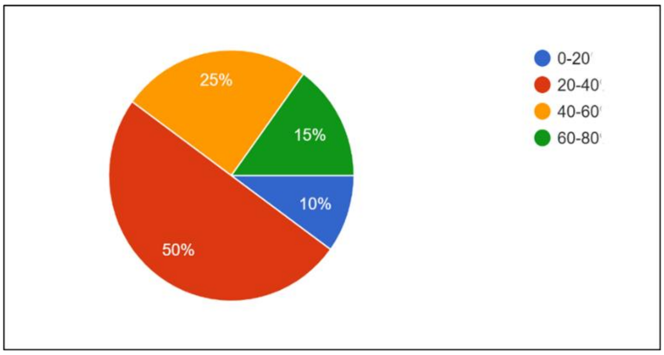

Fig.2: Demographic Information- Age of Respondents

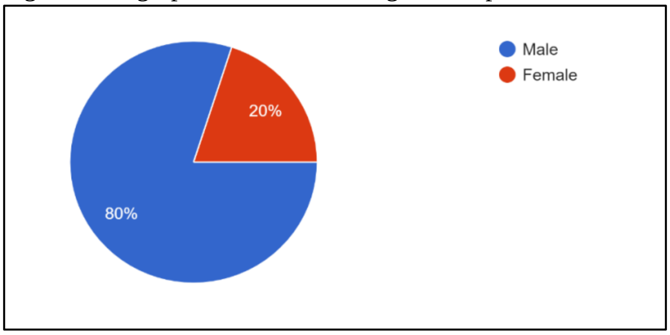

Fig.3: Demographic Information- Gender of Respondents

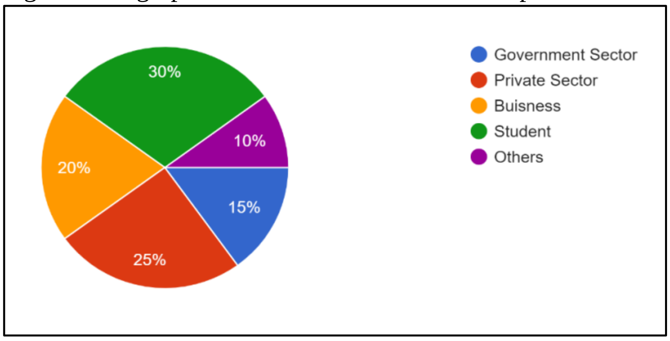

Fig.4: Demographic Information- Occupation of Respondents

in Section 2 i.e. General Perception, we collected data for four given questions, and the results are according to Fig. 5, 6, 7 & 8.

1. Do you use groundwater for drinking purposes?
2. Depth of Water Source
3. Are you aware of a dumping site near your locality?
4. If yes, how do you perceive its impact on the environment, particularly on water bodies?

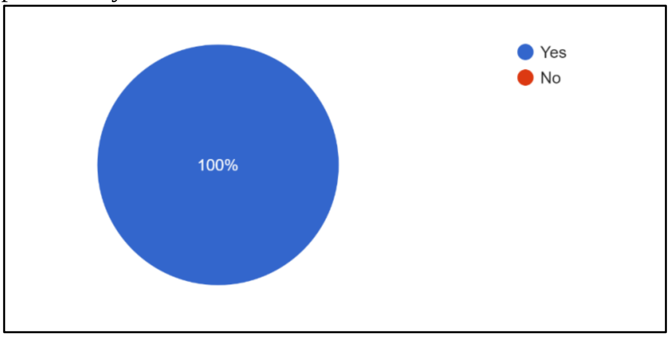

Fig.5: General Perception- Do you use groundwater for drinking purposes?

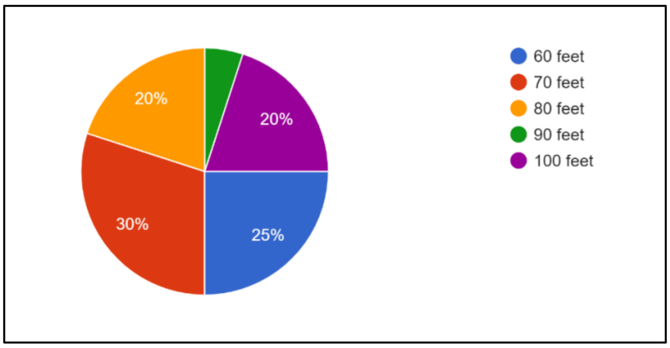

Fig.6: General Perception- Depth of water source

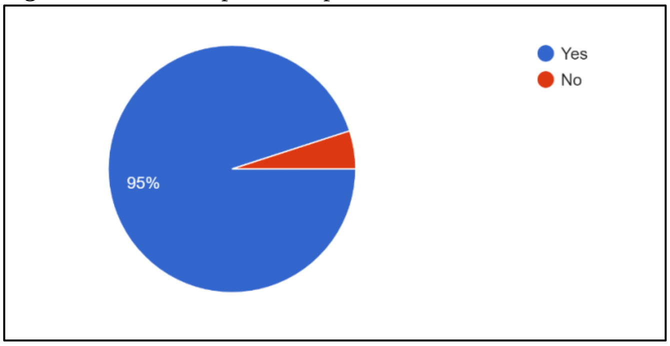

Fig.7: General Perception- Are you aware of a dumping site near your locality?

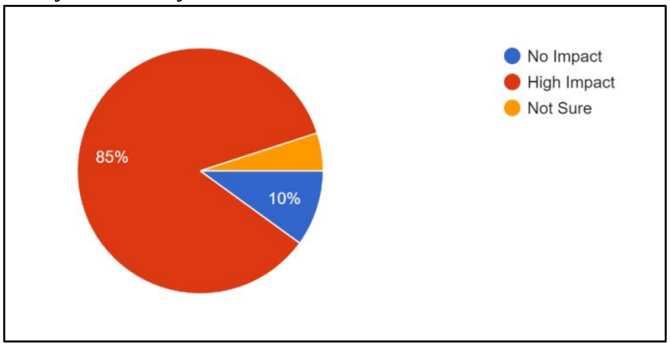

Fig.8: General Perception- how do you perceive its impact on the environment?

Then, in Section 3, i.e. Groundwater Quality Assessment, we collected data for four questions given below and the results are according to Fig. 9, 10, 11 & 12.

1. Have you experienced any changes in water quality in your area in recent years?
2. How often do you experience issues with the water supply? (e.g., discolouration, bad odour, taste issues, etc.)
3. Do you use additional water treatment or filtration systems at home?
4. Have you or anyone in your house experienced any health issues that you suspect could be related to water quality? (e.g., skin irritation, gastrointestinal problems, hair fall etc.)

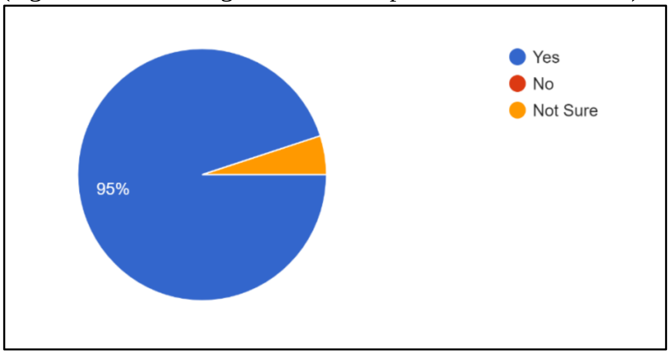

Fig.9: Groundwater Quality Assessment- Have you experienced any changes in water quality in your area in recent years

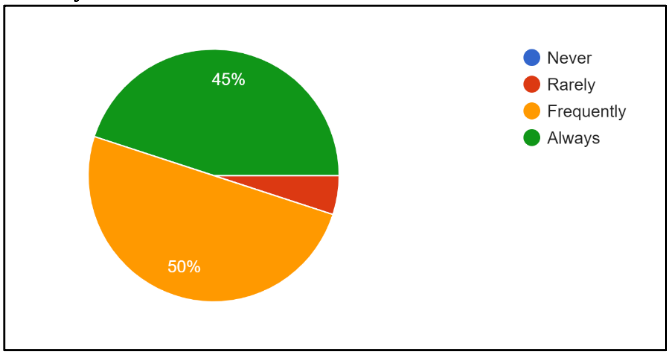

Fig.10: Groundwater Quality Assessment- How often do you Experience issues with the water supply?

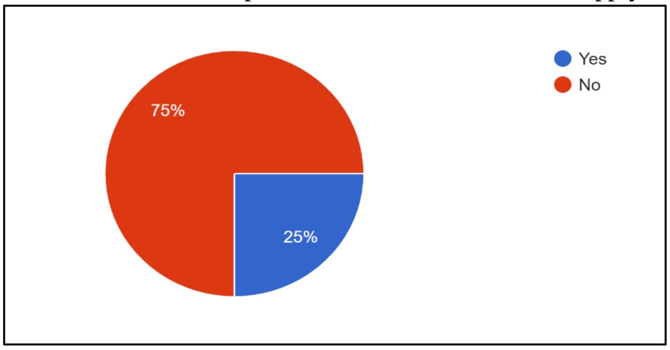

Fig.11: Groundwater Quality Assessment- Do you use additional water treatment or filtration systems at home?

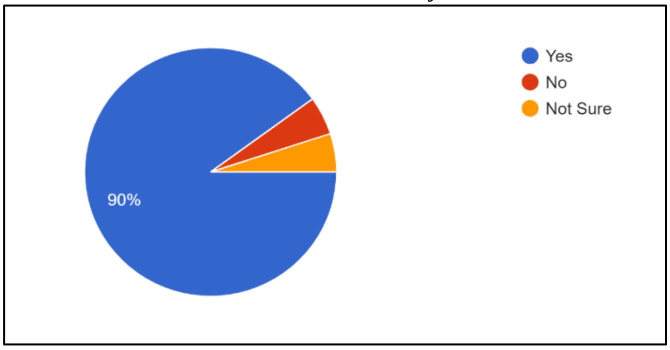

Fig.12: Groundwater Quality Assessment- Have you or anyone in your house experienced any health issues related to water quality?

Finally, in Section 4, i.e., Perceived Impact, we asked respondents two questions, and the results are shown in Figs. 13 and 14.

1. How concerned are you about the potential impact of the dumping site on water quality in your area?
2. Do you think the local government is taking adequate measures to address the issue of water contamination near the dumping site?

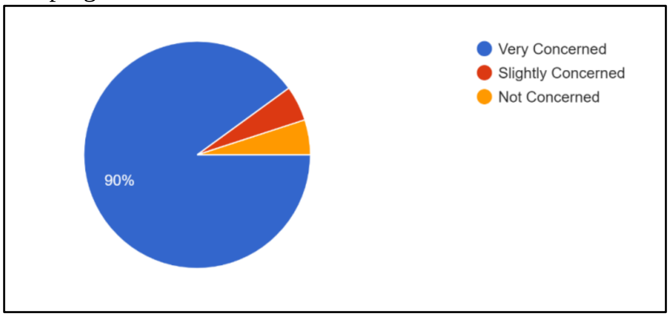

Fig.13: Perceived Impact: How concerned are you about the potential impact of the dumping site on water quality in your area?

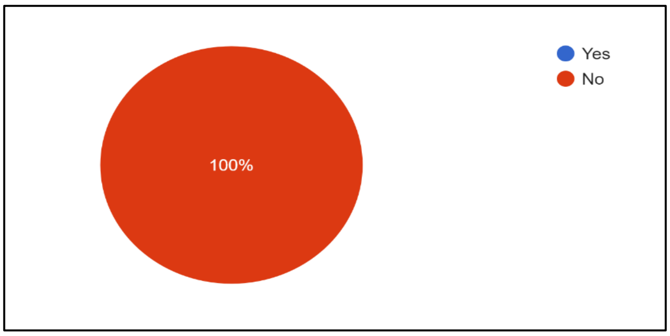

Fig.14: Perceived Impact: Do you think the local government is taking adequate measures to address the issue

The present study presents critical insights into waste management practices' environmental and public health implications in the study area. The findings reveal significant deterioration in groundwater quality near dumpsites, attributable to leachate infiltration and contamination from unregulated waste disposal (Kumar *et al.*,2016; Yadav *et al.* 2024). The survey highlighted elevated levels of pollutants such as heavy metals (e.g., lead, cadmium, and chromium) and other physicochemical parameters (e.g., pH, turbidity, total dissolved solids, and nitrate concentrations). These results suggest the failure of natural attenuation processes to mitigate leachate contamination, particularly in areas with high waste deposition and inadequate landfill liners. The elevated levels of nitrate and heavy metals have severe implications for public health (Ramalingam *et al.*, 2022). The affected communities, particularly those dependent on groundwater as a primary drinking source, are at an elevated risk.The findings align with prior research conducted in urban centres of India, such as Jaipur (Saini and Kaur, 2018), Jalandhar (Bhalla *et al.*, 2012), Raipur (Dahariya *et al.*, 2016), Nashik (Rajput *et al.*, 2021) and Chennai (Raman and Narayanan, 2008; Prasanna and Annadurai, 2016) where dumpsites have similarly been linked to groundwater quality deterioration. However, the study in Kanpur Nagar contributes unique insights due to the city's industrial activity, which exacerbates heavy metal contamination compared to predominantly municipal waste in other regions. This overlap between industrial and municipal waste poses a compounded risk to groundwater safety, a scenario less frequently documented in existing literature.

Recommendations

The study emphasizes the urgent need for policy interventions and robust waste management strategies in Kanpur Nagar. Recommendations include:

•Implementing engineered landfills with leachate collection and treatment systems.

•Regular groundwater monitoring programs around dumpsites to assess contamination trends.

•Educating local communities about the risks of using untreated groundwater.

•Promoting sustainable waste segregation and recycling to reduce leachate generation.

Limitations and Future Directions

•While the study provides a comprehensive qualitative assessment, several limitations warrant attention. For instance, seasonal variations in groundwater quality were not fully explored, which could influence contaminant levels due to rainfall and leachate dynamics. Additionally, incorporating advanced geospatial tools like GIS for contamination mapping and hydrological modelling would enhance the robustness of the findings.

•Future research should focus on the temporal dynamics of leachate contamination, the role of microbial communities in pollutant degradation, and the socioeconomic dimensions of groundwater dependency near dumpsites. Comparative studies across similar urban and peri-urban regions could also provide a broader understanding of the challenges and potential solutions.

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