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Socio-Economic and Environmental Challenges of Slum Dwellers in Aligarh City: Insights for Sustainable Urban Development

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Abstract: ***This study investigates the socio-economic conditions and environmental challenges faced by slum dwellers in Aligarh City, focusing on the interplay between indoor and outdoor environmental factors. The research employs a mixed-methods approach, including extensive field surveys, structured interviews, and spatial analysis using ArcGIS, to identify and analyze the living conditions within 28 slum spots identified. The findings highlight critical issues such as inadequate access to basic amenities, poor infrastructure, overcrowding, and exposure to environmental hazards, which collectively deteriorate the health and well-being of slum residents. Prevalent issues like respiratory and waterborne diseases underscore the need for improved sanitation, ventilation, and waste management practices. It advocates for participatory planning processes to ensure sustainable and equitable development. Furthermore, the research highlights the importance of aligning local governance with international standards, such as the Sustainable Development Goals (SDGs), to address urban poverty and foster community resilience. A multidimensional approach involving municipal corporations, urban planners, and non-governmental organizations is crucial to achieving inclusive urban development. This study contributes valuable insights into slum dynamics, offering practical recommendations for addressing socio-economic disparities and enhancing environmental health in urban slum settings.***
Keywords: Slum dwellers, Indoor environmental condition, Socio-economic conditions, Urban policy frameworks, Aligarh City, Sustainable urban development.

I. INTRODUCTION

In numerous cases, the urban poor reside unlawfully in areas considered unsuitable for habitation, rendering them officially invisible (Wright, 1997). Lacking legal authorization to occupy the land, these individuals are denied access to government support for essential sanitation and healthcare programs. Such living conditions not only impact those dwelling in these areas but also extend their influence to the broader city. Public health officials often regard slums and encampments as risks to the health and safety of people living or working nearby. Consequently, the hardships faced by the invisible population spill over into the visible sector, leading to recognized health outcomes (Wright, 1997). India's settlements are increasingly adopting urban characteristics, moving away from their traditional rural identity. However, this shift introduces a significant challenge: urban poverty, often overlooked in policies, programs, and governance. It is frequently stated that "there is no place for the poor in the town planning process." It is imperative for government policies and programs to prioritize the urban poor to ensure their inclusion in basic amenities. Such efforts would significantly reduce the disease burden by an estimated 70 to 80 percent.

People residing in impoverished areas frequently struggle to maintain adequate domestic hygiene due to a lack of awareness of health risks or an inability to afford basic necessities like toilet paper. Handwashing becomes a challenge in homes or shelters without running water, while safe food preparation and storage are nearly impossible in urban slums where water, sewage systems, and waste collection services are severely limited. An estimated 100 million urban residents across Asia, Africa, and Latin America resort to the "wrap and throw" method for open defecation due to the absence of household toilets. Public restrooms, when available, are often of poor quality, located far away, or too expensive. In urban settings, less than half of all solid waste is typically collected, with low-income neighborhoods having the least access to such services. This leads to waste accumulation in the streets, attracting disease-carrying pests and insects. These practices also have environmental repercussions, as waste often contaminates water supplies. When sewage is discharged into water bodies, seafood can quickly become tainted, leading to disease outbreaks such as hepatitis in Shanghai and cholera in Peru (Unite for Sight US, 2015).

Many urban poor live in overcrowded housing plagued by health risks such as mold, rats, and lead paint toxicity, which can result in infections, illnesses, and injuries. Poorly constructed buildings often harbor insects that spread diseases like dengue fever and malaria. Simultaneously, inadequate housing conditions exacerbate psychological health issues and nutritional deficiencies. Housing costs also impose a significant financial burden, leading to heightened stress and reduced funds for other essentials.

The challenges posed by informal housing settlements are intricately linked to the broader city infrastructure. Many of the described conditions are not only detrimental to the inhabitants but also difficult to address. As highlighted in the Water and Sanitation programs, constructing latrines or traditional sewers is particularly challenging in the crowded and narrow streets of peri-urban settlements. Nevertheless, some slum areas in Indian cities have begun finding innovative ways to mitigate these infrastructural challenges (Satterthwaite, 2003).

Inadequate sanitation is one of the clearest indicators of poverty and health challenges slum population. According to the World Health Organization, over 600 million urban residents live in substandard housing or areas afflicted by overcrowding and insufficient sanitation services, including access to potable water and proper waste disposal. Despite overall advancements in urban sanitation programs, the number of people lacking these essential services continues to grow. Over the past two decades, significant progress has been made in sanitation coverage; however, it remains disproportionately inaccessible to the urban poor. The UNDP-World Bank Water and Sanitation Program reported that in 1990, 453 million urban residents lacked sanitation services. By 1994, this figure had risen to 589 million, underscoring the difficulty of keeping pace with the growing population. Sanitation programs are being implemented at a slower rate than population growth, leaving an increasing number of people underserved. Moreover, the growing population contributes to overcrowding, further worsening sanitation conditions (Unite for Sight US, 2015).

Access to safe drinking water has long been recognized as a critical challenge for sustainable development. In most developing countries, including India, access to improved water supply is far from universal. Census 2011 reveals that 31.16 percent, or nearly one-third, of India's population resides in urban areas. Of these, approximately 13.9 million households, equating to 65 million people or 17.4 percent of urban households, live in slums, informal settlements, or are homeless. Many of these slums and informal settlements remain unrecognized and unnotified by the government, creating challenges for planning and program implementation. As a result, over 97 million people in India lack access to safe drinking water, significantly affecting health and morbidity (SLB National Handbook, 2011).

Sanitation issues, including inadequate waste disposal systems, are at the core of numerous fatal infectious diseases, many of which disproportionately affect children. Among these, diarrhea is one of the most widespread and is commonly found in populations with limited access to clean water. Other significant diseases linked to poor sanitation include dengue fever, cholera, and tuberculosis. Each year, approximately 827,000 individuals in low- and middle-income countries die due to inadequate potable water, sanitation, and hygiene, accounting for 60% of total diarrheal deaths. Poor sanitation is estimated to be the primary cause of 432,000 of these deaths. Although diarrhea remains a leading cause of death, it is largely preventable. Improved water, sanitation, and hygiene could avert the deaths of 297,000 children under five annually. Open defecation exacerbates a cycle of disease and poverty, with countries where this practice is most prevalent experiencing the highest rates of child mortality, malnutrition, poverty, and severe wealth disparities (WHO, 2019).

The challenges faced by the urban poor are increasingly evident in smaller cities like Aligarh, where sewer systems are either precarious or entirely absent, and space for toilets and waste disposal is scarce. Inequities are further aggravated when sewage from wealthier households is dumped into storm drains, waterways, or landfills, contaminating the residential areas of poorer communities.

As the leading international authority on public health, the World Health Organization (WHO) spearheads global efforts to prevent disease transmission and advises governments on health-based regulations. Regarding sanitation, the WHO monitors the global burden of disease and evaluates sanitation access, analyzing factors that facilitate or hinder progress. This monitoring provides member states and donors with critical global data to guide investments in toilet infrastructure and the safe management of wastewater and excreta. The WHO collaborates with partners to promote effective risk assessment and sanitation management practices within communities and health facilities through its Guidelines on Sanitation and Health, Safe Use of Wastewater, Recreational Water Quality, and the promotion of Sanitation Safety Planning. Additionally, the WHO supports the integration of WASH (Water, Sanitation, and Hygiene) initiatives with health programs targeting neglected tropical diseases, cholera, polio, and antimicrobial resistance. This research sought to evaluate the overall indoor environmental conditions of slum households in Aligarh city based on the parameters set by different national and international bodies.

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II. MATERIALS AND METHODS

A. *Study Area*

Aligarh, a key city in Uttar Pradesh, is situated in the western region of the state, approximately 126 kilometers from Delhi (Rahman et al., 2008). Spanning a total area of 98.5 km² (Fig. 1), the city lies in a fertile area between the Ganga and Yamuna rivers, with a UTM Zone of 44 N (Jamal et al. 2023). The region's physiography is characterized by level plains to moderately sloping terrain (less than 3%) from north to south, interspersed with natural depressions such as paleochannels and oxbow lakes (Saha et al., 1990; Asif, 2014). Its topography resembles a shallow trough with a saucepan-like form, situated at an altitude of approximately 187 meters above sea level. The fertile alluvial soil supports a thriving agricultural industry, while the lock industry provides significant employment opportunities for the city's population. Aligarh's rich history, shaped by the Mughal, Maratha, and British periods, is complemented by its tropical monsoon climate, characterized by uneven and inadequate precipitation, with annual rainfall ranging from 60 to 75 cm (Sharma & Vashishtha, 2023). Summers are extremely hot, with temperatures reaching up to 46°C in June, while winters are frigid, with January temperatures ranging from 7°C to 21°C. The city's average annual temperature is 29.24°C, which is 3.27% higher than India's average, and relative humidity in the afternoons is typically low, ranging from 2% to 3%. The city's topography features a gentle slope from north to south, with a southeast swing, similar to other parts of the Gangetic plain. The region's vegetation is predominantly subtropical deciduous, with dhak jungles historically cleared for agriculture (Ajmal & Jamal, 2021; Khan & Butool, 2013). Rapid urbanization and population growth have led to a continuous expansion of the city, transforming vacant and agricultural land into built-up areas and significantly altering land use patterns over the years. The Aligarh Municipal Corporation has identified 28 slum clusters, referred to as "Maleen Bastee," (Fig. 2) highlighting a complex interplay between socio-economic conditions and indoor pollution in the context of slum dwellings. These factors, combined with the city's climatic extremes and seasonal rhythms, make Aligarh a critical area of study for examining the socio-economic and environmental challenges faced by the slum population.

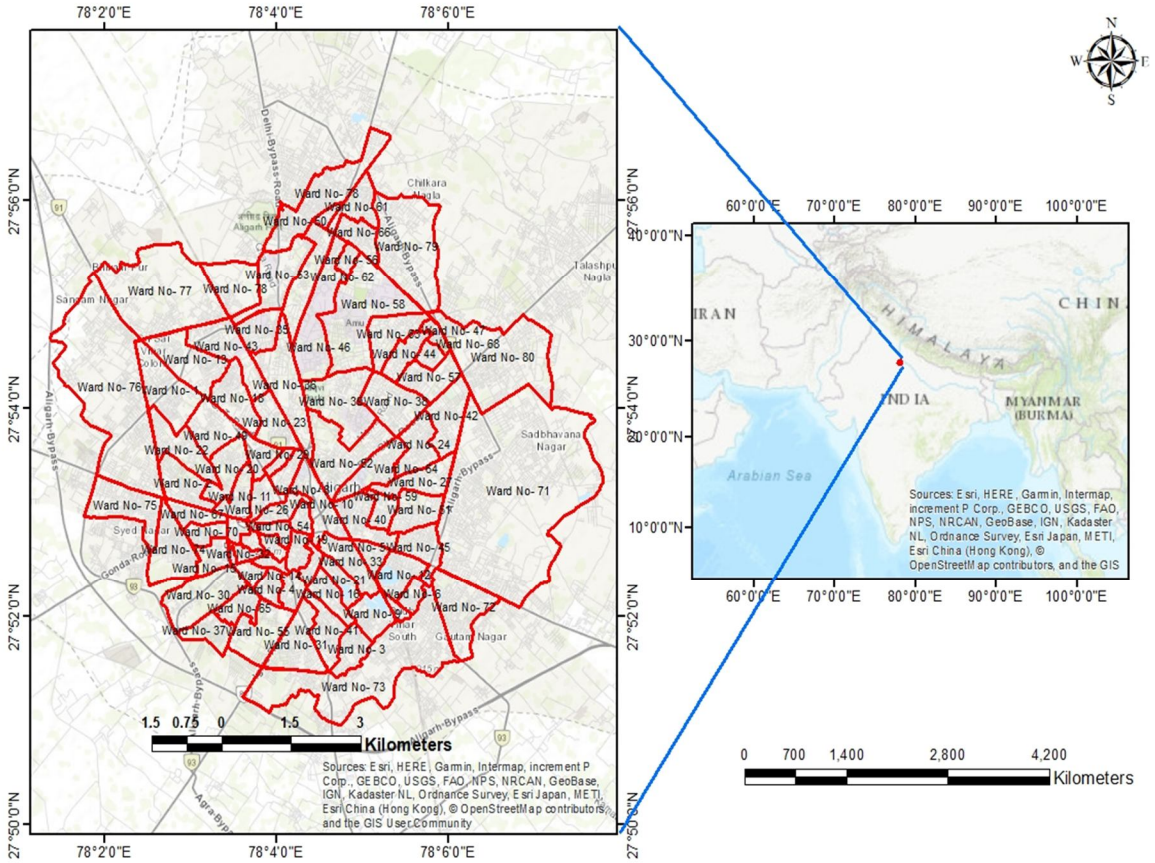

Fig. 1 Geographical location of the study area

III. DATABASE

The study primarily relied on primary data collected through various field activities, including city surveys to identify slum spots, in-depth surveys of selected slum areas, structured household surveys, and interviews with slum dwellers, local residents, municipal workers, and government officials. Fieldwork, conducted in 2024, focused on gathering both qualitative and quantitative data to capture the unique socio-economic and environmental challenges faced by slum residents. Women were primarily chosen as respondents due to their familiarity with household conditions, and frequent visits were made to ensure the accuracy and reliability of the data. A stratified random sampling technique was employed, ensuring representation across diverse socio-economic strata. A total of 1120 households, sampled from 28 slum spots identified by the Aligarh Municipal Corporation (40 households per slum spot), provided statistically significant and representative data. The study also incorporated indoor environmental assessments, focusing on factors such as Status and Conditions of Houses, ventilation, overcrowding, sanitation, and water supply given their direct impact on health conditions.

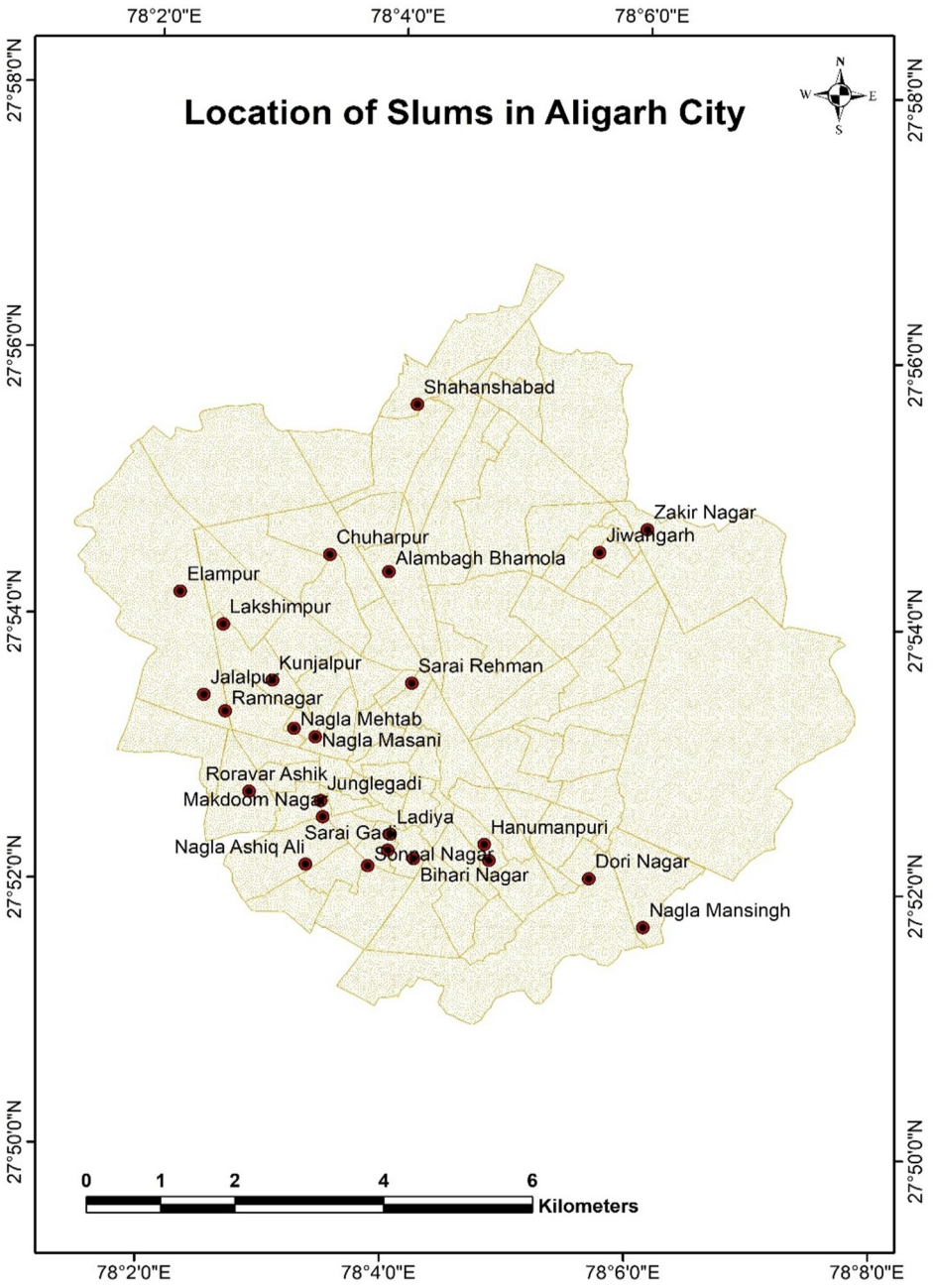

Fig. 2 Geographical location of 28 slums in Aligarh city

IV. METHODOLOGY

The identification of slum spots followed internationally recognized criteria, including definitions by the USA Housing Act of 1949, UN-HABITAT (2003), and the Census of India (2001). These spots were mapped using ArcGIS software to enable spatial analysis of their distribution across Aligarh City. Data collection was conducted through structured interviews with respondents using a detailed questionnaire that covered household profiles, living conditions, and livelihoods. Personal visits to each household were conducted twice to verify the information, and efforts were made to create a comfortable environment to encourage candid responses. The team addressed initial reluctance among some residents through extended engagement. The data collection process spanned approximately one year, during which household survey data and indoor environmental quality measurements were compiled and cross-verified. Once collected, the data were tabulated and entered into spreadsheets for further analysis, ensuring a comprehensive understanding of the socio-economic conditions and indoor environmental challenges in Aligarh's slums.

V. RESULTS AND DISCUSSION

A. *Status and Conditions of Houses*

The data presented in Table 1 highlights the living conditions and housing status in the slums of Aligarh City, reflecting the socio-economic challenges faced by its dwellers. The table categorizes housing structures into mud and thatched, bricks and straw, and wood and straw, and analyzes roof leakage and overcrowding issues. Bricks and straw houses dominate the majority of slums, with 100% prevalence in areas like Sarai Rehman, Dori Nagar, and Hanumanpuri, suggesting relative permanence in housing. However, significant proportions of mud and thatched houses in slums such as Bihari Nagar (30%), Nagla Ashiq Ali (30%), and Shahanshabad (30%) indicate economic disparities and substandard living conditions. Notably, Bhagwan Nagar and Jalalpur stand out for their use of wood and straw housing, comprising 60% and 40% of structures, respectively. Roof leakage is a critical problem in slums such as Bihari Nagar, Sarai Gadi, and Shahanshabad, where 100% of the roofs leak, exposing residents to environmental vulnerabilities, while others like Sarai Rehman and Dori Nagar report no leakage, indicating better-quality construction or maintenance. Overcrowding is uniformly prevalent across the slums, with 100% of the population residing in spaces of 12-20 square feet per person, underscoring severe spatial constraints and lack of urban planning. The absence of households with less than 10 square feet per person may reflect a baseline in overcrowding, but the overall lack of adequate living space remains a pressing concern. The table reveals stark inequalities in housing quality, with some slums like Zakir Nagar showing a heavy reliance on mud structures (70%), while others like Sonpal Nagar and Chuharpur are entirely brick-based. These disparities highlight the socio-economic divides and uneven distribution of resources. Furthermore, slums with entirely brick-based housing, such as Alambagh Bhamola and Nagla Masani, still experience overcrowding, illustrating that structural permanence does not necessarily equate to improved living conditions. The widespread nature of these challenges emphasizes the urgent need for targeted interventions to improve housing, address overcrowding, and enhance the quality of life for slum dwellers in Aligarh City.

Table 1: Status and Conditions of Houses(Figures in Percentage)

Slum	Type of slum house			Leaking roof		Overcrowding (floor space per person)	
	Mud + thatched	Bricks/straw	Wood/straw	Yes	No	10 sq. feet	12-20 sq. feet
Sarai Rehman	0	100	0	0	100	0	100
Dori nagar	0	100	0	0	100	0	100
Hanumanpuri	0	100	0	0	100	0	100
Bhagwan Nagar	0	40	60	0	100	0	100
Bihari Nagar	30	70	0	100	0	0	100
Sarai Gadi	20	80	0	100	0	0	100

Nagla Ashiq Ali	30	70	0	100	0	0	100
Junglegadi	20	80	0	100	0	0	100
Makdoom Nagar	20	80	0	100	0	0	100
Roravar Ashik	0	100	0	0	100	0	100
Ladiya	0	100	0	0	100	0	100
Sonpal Nagar	0	100	0	0	100	0	100
Ramnagar	0	100	0	0	100	0	100
Chuharpur	0	100	0	0	100	0	100
Lakshimpur	20	80	0	100	0	0	100
Sarai Gadi	0	100	0	0	100	0	100
Alambagh Bhamola	0	100	0	0	100	0	100
Nagla Masani	0	100	0	0	100	0	100
Nagla Mehtab	0	100	0	0	100	0	100
Kunjalpur	0	100	0	0	100	0	100
Nagla Molvi	0	100	0	0	100	0	100
Shahanshabad	30	70	0	100	0	0	100
Jiwangarh	0	100	0	0	100	0	100
Zakir Nagar	70	30	0	0	100	0	100
Nagla Mansingh	0	100	0	100	0	0	100
Elampur	0	100	0	0	100	0	100
Jalalpur	40	60	0	100	0	0	100
Manzoorgadi	0	100	0	0	100	0	100
Overall	10.00	87.86	2.14	32.14	67.86	0.00	100.00

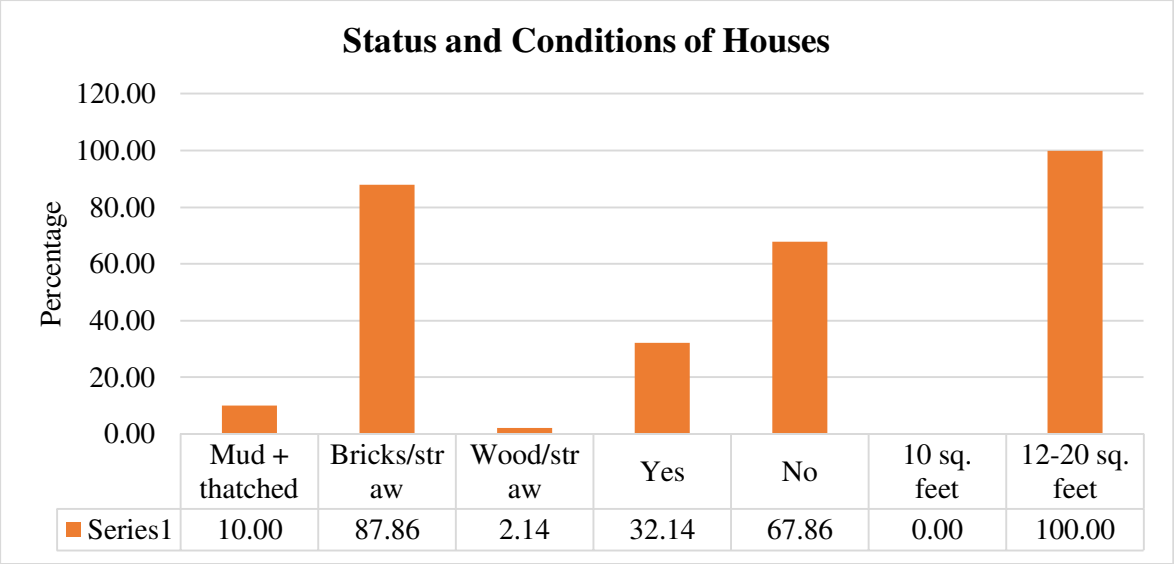

Fig. 3 Status and Conditions of Houses

B. Status And Conditions Of Kitchen

The data presented in Table 2 provides a comprehensive overview of the status and conditions of kitchens in the slums of Aligarh City, highlighting the challenges faced by the residents concerning indoor cooking environments. It is evident that none of the households across all surveyed slums have separate kitchens or utilize open-air verandahs for cooking, with 100% of the cooking activities taking place in multipurpose rooms. This setup reflects the lack of dedicated kitchen spaces, contributing to poor indoor air quality and health risks for residents. Additionally, the data reveals that no cooking is performed under chimneys in any of the slums, further exacerbating the issue of smoke accumulation indoors.

The intensity of exposure to smoke during cooking is significant, as 100% of households experience exposure for one hour, underscoring prolonged contact with harmful pollutants and highlighting a severe health hazard, particularly for women and children who spend more time in these environments. Moreover, 100% of the households report smoke infiltration into the living areas, indicating inadequate ventilation and compounding the risks of respiratory illnesses. This uniformity in kitchen conditions across all surveyed slums—from Sarai Rehman and Dori Nagar to Manzoorgadi—reflects a systemic lack of basic infrastructure and amenities necessary for safe and healthy cooking practices. The absence of chimneys or alternative smoke outlets, coupled with the multipurpose usage of living spaces, points to a broader socio-economic issue, where resource constraints and lack of urban planning perpetuate unsafe living conditions. This data underscores the urgent need for targeted interventions, such as the introduction of improved cookstoves, enhanced ventilation systems, and education on safe cooking practices, to mitigate the adverse health and environmental impacts of current kitchen conditions in the slums of Aligarh City. These findings align with the research paper's focus on evaluating the socio-economic and environmental challenges faced by slum dwellers, offering crucial insights into the indoor environment and its implications for overall quality of life.

Table 2: Status and Conditions of Kitchen(Figures in Percentage)

Slum	Place of cooking food			Cooking done under a chimney		Intensity of exposure to smoke while cooking		Smoke in house from kitchen	
	Separate kitchen	Open air/ varandah	Multipurpose room	Yes	No	½ hrs	1 hr	Yes	No
Sarai Rehman	0	0	100	0	100	0	100	100	0
Dori nagar	0	0	100	0	100	0	100	100	0
Hanumanpuri	0	0	100	0	100	0	100	100	0
Bhagwan Nagar	0	0	100	0	100	0	100	100	0
Bihari Nagar	0	0	100	0	100	0	100	100	0
Sarai Gadi	0	0	100	0	100	0	100	100	0
Nagla Ashiq Ali	0	0	100	0	100	0	100	100	0
Junglegadi	0	0	100	0	100	0	100	100	0
Makdoom Nagar	0	0	100	0	100	0	100	100	0
Roravar Ashik	0	0	100	0	100	0	100	100	0
Ladiya	0	0	100	0	100	0	100	100	0
Sonpal Nagar	0	0	100	0	100	0	100	100	0
Ramnagar	0	0	100	0	100	0	100	100	0
Chuharpur	0	0	100	0	100	0	100	100	0
Lakshimpur	0	0	100	0	100	0	100	100	0
Sarai Gadi	0	0	100	0	100	0	100	100	0
Alambagh Bhamola	0	0	100	0	100	0	100	100	0
Nagla Masani	0	0	100	0	100	0	100	100	0
Nagla Mehtab	0	0	100	0	100	0	100	100	0
Kunjalpur	0	0	100	0	100	0	100	100	0
Nagla Molvi	0	0	100	0	100	0	100	100	0
Shahanshabad	0	0	100	0	100	0	100	100	0
Jiwangarh	0	0	100	0	100	0	100	100	0
Zakir Nagar	0	0	100	0	100	0	100	100	0
Nagla Mansingh	0	0	100	0	100	0	100	100	0
Elampur	0	0	100	0	100	0	100	100	0
Jalalpur	0	0	100	0	100	0	100	100	0
Manzoorgadi	0	0	100	0	100	0	100	100	0
Overall	0.00	0.00	100.00	0.00	100.00	0.00	100.00	100.00	0.00

C. Kitchen Waste Management And Safety Measure Of House

The data from Table 3 provides an insightful understanding of kitchen waste management and fire safety measures among the slum households in Aligarh City, shedding light on significant gaps in environmental and household safety practices. A striking 100% of the households across most slums, including Sarai Rehman, Dori Nagar, Hanumanpuri, and Bhagwan Nagar, dispose of kitchen waste immediately outside, with no efforts toward composting or the use of common bins, demonstrating a uniform lack of sustainable waste disposal mechanisms. However, some exceptions are observed in slums like Makdoom Nagar, Roravar Ashik, and Chuharpur, where 20–40% of households reportedly use common bins, signaling slight but inadequate steps towards structured waste management. Notably, the separation of recyclable materials from household waste is absent across all surveyed slums, with a staggering 100% of respondents failing to adopt this critical environmental practice. This uniform absence highlights the need for community awareness and resources to promote recycling and waste segregation. Additionally, fire safety measures in households are universally absent, as evidenced by 100% of respondents across all slums indicating a lack of fire safety provisions. This severe deficiency reflects systemic neglect in ensuring household safety standards, leaving residents vulnerable to fire hazards. The uniformity of these trends across diverse slums, from Nagla Molvi and Shahanshabad to Zakir Nagar and Manzoorgadi, points to a broader structural issue rooted in poverty, inadequate urban planning, and limited access to public health resources. These findings emphasize the urgency of implementing comprehensive waste management systems, recycling initiatives, and fire safety programs tailored to slum communities. Addressing these gaps would significantly improve the living conditions and environmental safety of the slum dwellers, aligning with the research's focus on enhancing socio-economic and environmental sustainability in Aligarh City's slum areas.

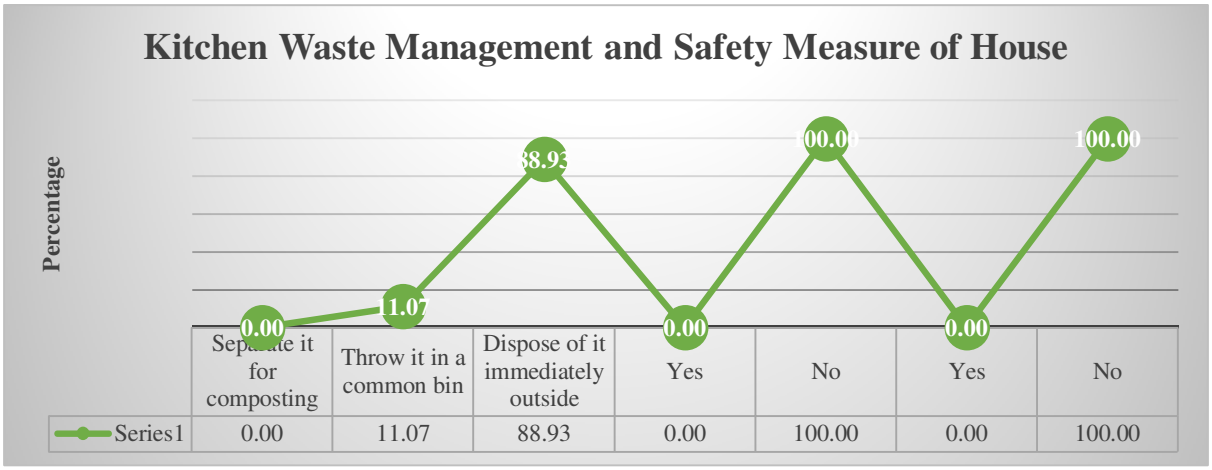

Fig. 4 Kitchen Waste Management and Safety Measure of House

Table 3: Kitchen Waste Management and Safety Measure of House(Figures in Percentage)

Slum	Dispose of kitchen waste inside house			Separate recyclable materials from household		Fire safety measures in house	
	Separate it for composting	Throw it in a common bin	Dispose of it immediately outside	Yes	No	Yes	No
Sarai Rehman	0	0	100	0	100	0	100
Dori nagar	0	0	100	0	100	0	100

Hanumanpuri	0	0	100	0	100	0	100
Bhagwan Nagar	0	0	100	0	100	0	100
Bihari Nagar	0	0	100	0	100	0	100
Sarai Gadi	0	0	100	0	100	0	100
Nagla Ashiq Ali	0	0	100	0	100	0	100
Junglegadi	0	0	100	0	100	0	100
Makdoom Nagar	0	20	80	0	100	0	100
Roravar Ashik	0	30	70	0	100	0	100
Ladiya	0	20	80	0	100	0	100
Sonpal Nagar	0	0	100	0	100	0	100
Ramnagar	0	0	100	0	100	0	100
Chuharpur	0	40	60	0	100	0	100
Lakshimpur	0	0	100	0	100	0	100
Sarai Gadi	0	0	100	0	100	0	100
Alambagh Bhamola	0	30	70	0	100	0	100
Nagla Masani	0	40	60	0	100	0	100
Nagla Mehtab	0	0	100	0	100	0	100
Kunjalpur	0	30	70	0	100	0	100
Nagla Molvi	0	10	90	0	100	0	100
Shahanshabad	0	30	70	0	100	0	100
Jiwangarh	0	20	80	0	100	0	100
Zakir Nagar	0	40	60	0	100	0	100
Nagla Mansingh	0	0	100	0	100	0	100
Elampur	0	0	100	0	100	0	100
Jalalpur	0	0	100	0	100	0	100
Manzoorgadi	0	0	100	0	100	0	100
Overall	0.00	11.07	88.93	0.00	100.00	0.00	100.00

D. Sources and Duration Of Water Supply

Table 4 highlights the sources and duration of water supply among slum households in Aligarh City, offering critical insights into the disparities in access and reliability of water resources, which significantly impact the socio-economic and environmental conditions of slum dwellers. The data reveals that public water sources overwhelmingly dominate, with 100% dependence in several slums, such as Sarai Rehman, Nagla Ashiq Ali, Junglegadi, Makdoom Nagar, and others, indicating a heavy reliance on government or communal infrastructure for basic water needs. Private water supply is available only in limited areas, with the highest percentages seen in Bhagwan Nagar (40%) and Sarai Gadi (40%), while other slums such as Dori Nagar (20%), Hanumanpuri (30%), and Bihari Nagar (30%) demonstrate moderate access, reflecting unequal distribution of resources. Regarding the duration of water supply, the study shows variations across slums. A significant number of households in slums such as Sarai Rehman (80%), Dori Nagar (70%), and Hanumanpuri (60%) receive water for 13-18 hours a day, suggesting relatively better water availability. In contrast, other slums like Ladiya (80%), Nagla Molvi (100%), and Shahanshabad (80%) receive water for only 7-12 hours a day, highlighting a critical gap in water supply duration. Notably, slums such as Elampur stand out with 100% of households receiving water for only 7-12 hours, indicating extreme inadequacy. Conversely, some slums like Jalalpur (70%) and Nagla Mansingh (70%) benefit from longer durations of supply, which improves daily water availability. The reliance on public water sources combined with limited hours of water supply presents a concerning picture of water scarcity, poor infrastructure, and potential health and hygiene challenges in these communities. These disparities also reflect broader socio-economic inequalities, as private water access is often associated with better living standards and greater financial capability. Additionally, the variability in supply duration across different slums indicates uneven service delivery and planning, with some areas being more underserved than others. Addressing these water supply issues is vital for improving the quality of life, enhancing public health, and fostering sustainable development in slum areas. Investments in equitable water infrastructure, efficient resource distribution, and community-based water management practices are necessary to mitigate these challenges.

These findings underline the urgent need for targeted interventions to ensure consistent and equitable access to water resources, which is fundamental for addressing the broader socio-economic and environmental issues faced by slum dwellers in Aligarh City.

Table 4: Sources and Duration of Water Supply(Figures in Percentage)

Slum	Sources of water supply		Duration of water supply	
	Private	Public	7-12 hrs	13-18 hrs
Sarai Rehman	0	100	20	80
Dori nagar	20	80	30	70
Hanumanpuri	30	70	40	60
Bhagwan Nagar	40	60	60	40
Bihari Nagar	30	70	30	70
Sarai Gadi	40	60	40	60
Nagla Ashiq Ali	0	100	40	60
Junglegadi	0	100	50	50
Makdoom Nagar	0	100	40	60
Roravar Ashik	0	100	60	40
Ladiya	0	100	80	20
Sonpal Nagar	0	100	60	40
Ramnagar	0	100	50	50
Chuharpur	0	100	60	40
Lakshimpur	20	80	20	80
Sarai Gadi	0	100	70	30
Alambagh Bhamola	30	70	30	70
Nagla Masani	20	80	20	80
Nagla Mehtab	30	70	30	70
Kunjalpur	30	70	30	70
Nagla Molvi	0	100	0	100
Shahanshabad	20	80	20	80
Jiwangarh	30	70	30	70
Zakir Nagar	20	80	20	80
Nagla Mansingh	0	100	70	30
Elampur	0	100	100	0
Jalalpur	40	60	70	30
Manzoorgadi	0	100	50	50
Overall	14.29	85.71	43.57	56.43

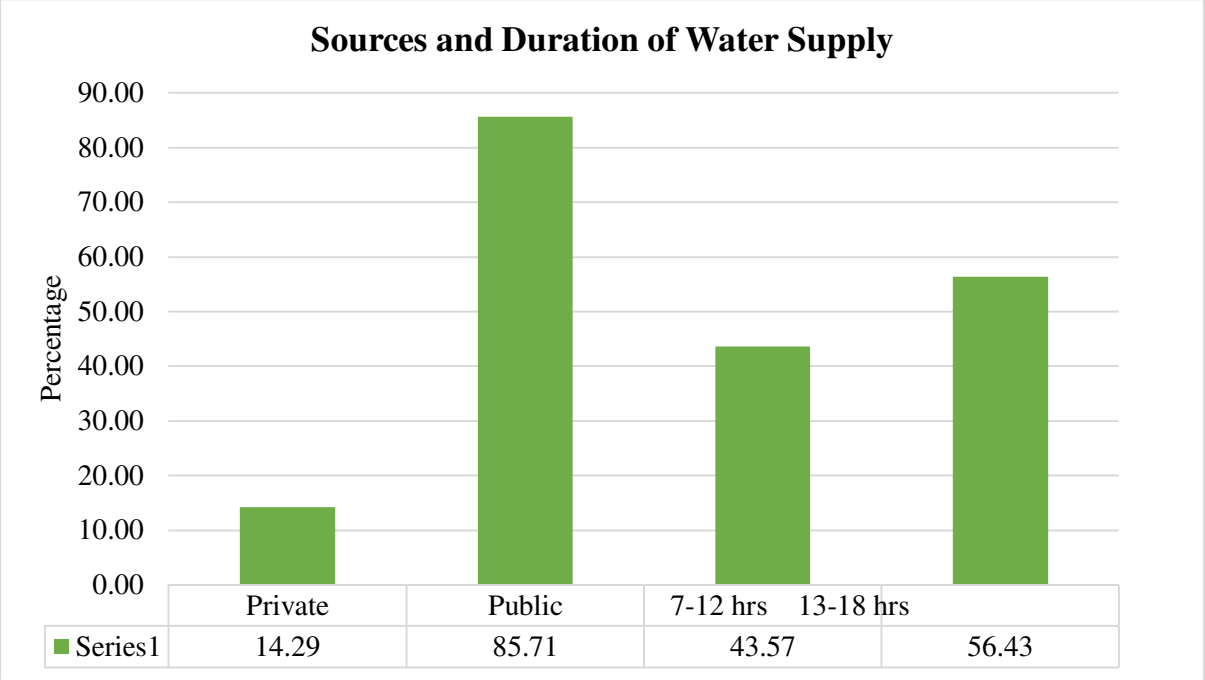

Fig. 5 Sources and Duration of Water Supply

E. Quality Of Water For Drinking And Cooking

Table 5 offers a comprehensive analysis of the quality of water for drinking and cooking in the slums of Aligarh City, revealing significant disparities in water sources, problems with water quality, and household efforts to ensure water safety. The data illustrates a heavy reliance on public tube wells, with most slums like Sarai Rehman, Nagla Ashiq Ali, and Elampur reporting complete dependence (100%) on this source, while private tube wells serve as a supplementary or alternative option in a few slums such as Alambagh Bhamola (80%) and Manzoorgadi (80%). This reliance highlights the limited access to independent water resources in the majority of these communities. Concerning the quality of water, a considerable portion of slums report issues, with Bhagwan Nagar, Bihari Nagar, Nagla Ashiq Ali, and Makdoom Nagar showing 80% of respondents dissatisfied with the water quality. Conversely, in slums like Roravar Ashik, Ladiya, and Sarai Gadi, no issues with water quality were reported, suggesting localized disparities in water infrastructure or environmental conditions. Despite these challenges, an alarming trend is the lack of water treatment practices across all slums, with 100% of households reporting that they do not take any measures, such as boiling or filtering, to make water safer for consumption. This highlights a critical gap in awareness, affordability, or access to resources needed for water purification, which could lead to severe health risks. Interestingly, slums with higher dependence on private tube wells, such as Alambagh Bhamola and Manzoorgadi, report fewer quality issues, potentially reflecting the better maintenance or management of privately owned resources. However, slums like Bhagwan Nagar, despite significant private tube well usage (40%), still experience widespread dissatisfaction with water quality, indicating that private access alone does not ensure quality. Additionally, slums such as Shahanshabad and Sonpal Nagar, where a balance between public and private tube wells exists, show moderate levels of quality concerns, with 60% and 70% of households, respectively, reporting issues. The absence of water treatment efforts across all slums underlines an urgent need for interventions in education and infrastructure. Programs promoting affordable water purification techniques, coupled with improvements in public water infrastructure, are essential to mitigate health risks posed by contaminated water. Furthermore, the higher dependence on public tube wells among slums underscores the necessity for robust maintenance and regular quality checks of these communal resources. The findings from this table emphasize the socio-economic vulnerability of slum dwellers in Aligarh City, where limited access to safe drinking and cooking water directly affects health outcomes and quality of life. Addressing these issues requires a multi-faceted approach involving policy reforms, community engagement, and investments in sustainable water management systems.

Table 5: Quality of Water for Drinking and Cooking(Figures in Percentage)

Slum	Principle water source for drinking and cooking		Problem with the quality of water source for drinking and cooking		Treatment of water in any way to make it safer to drink	
	Private tube well	Public tube well	Yes	No	Yes	No
Sarai Rehman	10	100	30	70	0	100
Dori nagar	20	80	20	80	0	100
Hanumanpuri	30	70	70	30	0	100
Bhagwan Nagar	40	60	80	20	0	100
Bihari Nagar	30	70	80	20	0	100
Sarai Gadi	40	60	70	30	0	100
Nagla Ashiq Ali	0	100	80	20	0	100
Junglegadi	30	100	70	30	0	100
Makdoom Nagar	40	60	80	20	0	100
Roravar Ashik	30	70	0	0	0	100
Ladiya	60	40	0	0	0	100
Sonpal Nagar	30	70	60	40	0	100
Ramnagar	60	40	70	30	0	100
Chuharpur	70	100	20	80	0	100
Lakshimpur	30	70	30	70	0	100
Sarai Gadi	70	30	0	0	0	100
Alambagh Bhamola	80	20	30	70	0	100
Nagla Masani	40	60	80	20	0	100
Nagla Mehtab	50	70	40	60	0	100
Kunjalpur	30	70	0	100	0	100
Nagla Molvi	40	100	0	100	0	100
Shahanshabad	20	80	60	40	0	100
Jiwangarh	30	70	30	70	0	100
Zakir Nagar	20	80	20	80	0	100
Nagla Mansingh	30	100	20	80	0	100
Elampur	0	100	60	40	0	100
Jalalpur	40	60	80	20	0	100
Manzoorgadi	80	100	10	90	0	100
Overall	37.50	72.50	42.50	46.79	0.00	100.00

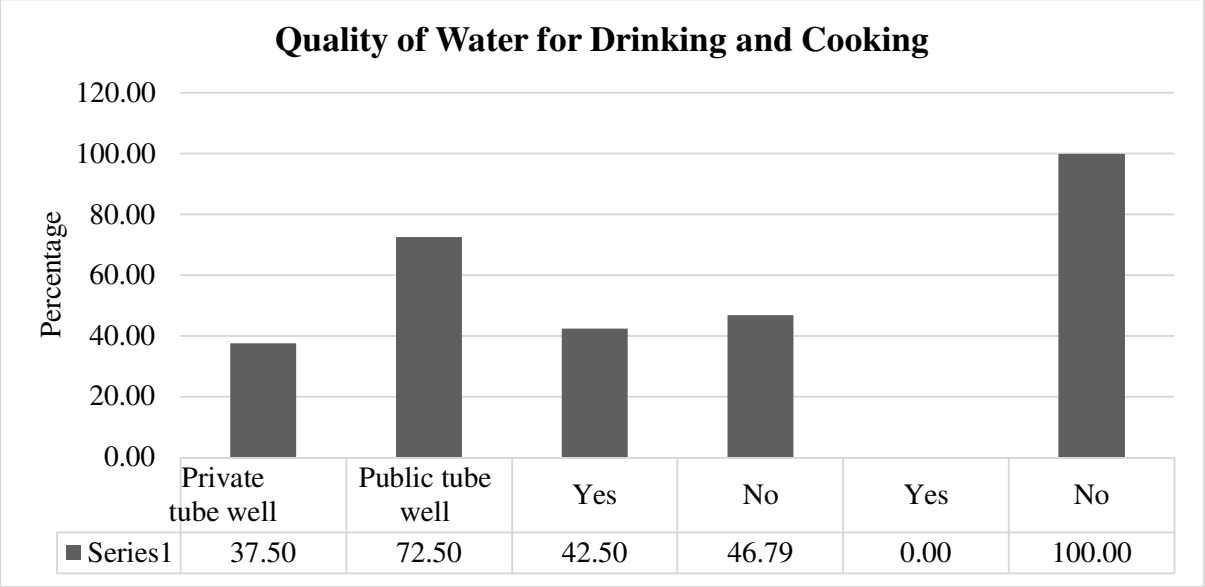

Fig. 6 Quality of Water for Drinking and Cooking

F. Condition of Storage and Cleanliness of Water for Drinking and Cooking

Table 6 provides an in-depth analysis of water storage practices and cleanliness habits among slum dwellers in Aligarh City, shedding light on their socio-economic conditions and the challenges they face in maintaining safe water for drinking and cooking. The data indicates a significant preference for open plastic containers for water storage across most slums, with slums like Sarai Rehman, Nagla Ashiq Ali, Junglegadi, Roravar Ashik, and Sonpal Nagar reporting 100% reliance on open containers. Closed plastic containers, which are comparatively more hygienic, are utilized to some extent in slums such as Bhagwan Nagar (40%), Sarai Gadi (40%), and Alambagh Bhamola (30%), but their use remains limited. This overwhelming dependence on open containers highlights the lack of access to secure and clean storage options, increasing the risk of water contamination.

When it comes to cleanliness practices, a considerable disparity is evident in the frequency of cleaning water storage containers. Slums such as Sarai Rehman, Nagla Ashiq Ali, Junglegadi, Roravar Ashik, and Sonpal Nagar demonstrate exemplary habits, with 100% of households cleaning their containers daily. Similarly, slums like Nagla Masani, Shahanshabad, and Zakir Nagar report high daily cleaning rates (80%), indicating a strong awareness of the importance of water cleanliness in these areas. However, in several other slums, weekly or even monthly cleaning practices dominate. For instance, Dori Nagar shows a worrying trend, with 80% of households cleaning containers weekly and 20% monthly. Bhagwan Nagar, Sarai Gadi, and Jalalpur also exhibit similar patterns, where a significant portion of households clean their containers weekly (60%), but a notable percentage (40%) delays cleaning to a monthly basis. This irregularity in cleanliness practices poses a significant health risk, particularly in densely populated areas with limited sanitation infrastructure.

The data underscores the lack of uniformity in water storage and cleanliness practices, reflecting the socio-economic challenges of these communities. While some slums demonstrate good habits, the widespread use of open containers and infrequent cleaning in many others highlight critical gaps in resources, awareness, and infrastructure. The high reliance on open containers suggests an urgent need for interventions, such as affordable and accessible closed storage solutions, to mitigate the risk of waterborne diseases. Moreover, awareness campaigns focusing on the importance of regular cleaning, coupled with community engagement programs, can play a crucial role in promoting better hygiene practices.

This table provides valuable insights into the vulnerabilities of slum dwellers in Aligarh City, emphasizing the interplay between limited resources, socio-economic constraints, and environmental health. Addressing these challenges requires a comprehensive strategy that combines infrastructure development, education, and policy support to improve water safety and public health in these marginalized communities. The findings from this table underline the urgent need for targeted interventions to enhance the overall quality of life for slum dwellers, particularly in relation to water safety and hygiene.

Table 6: Condition of Storage and Cleanliness of Water for Drinking and Cooking(Figures in Percentage)

Slum	Storage of water		Clean water container			
	Open Plastic container	Closed plastic container	Daily	Weekly	Fortnightly	Monthy
Sarai Rehman	100	0	100	0	0	0
Dori nagar	80	20	0	80	0	20
Hanumanpuri	70	30	70	0	0	30
Bhagwan Nagar	60	40	0	60	0	40
Bihari Nagar	70	30	70	0	0	30
Sarai Gadi	60	40	0	60	0	40
Nagla Ashiq Ali	100	0	100	0	0	0
Junglegadi	100	0	100	0	0	0
Makdoom Nagar	100	0	0	100	0	0
Roravar Ashik	100	0	100	0	0	0
Ladiya	100	0	100	0	0	0
Sonpal Nagar	100	0	100	0	0	0
Ramnagar	100	0	100	0	0	0
Chuharpur	100	0	100	0	0	0
Lakshimpur	80	20	80	0	0	20
Sarai Gadi	100	0	100	0	0	0
Alambagh Bhamola	70	30	0	70	0	30
Nagla Masani	80	20	80	0	0	20
Nagla Mehtab	70	30	70	0	0	30
Kunjalpur	70	30	70	0	0	30
Nagla Molvi	100	0	0	100	0	0
Shahanshabad	80	20	80	0	0	20
Jiwangarh	70	30	70	0	0	30
Zakir Nagar	80	20	80	0	0	20
Nagla Mansingh	100	0	100	0	0	0
Elampur	100	0	0	100	0	0
Jalalpur	60	40	60	0	0	40
Manzoorgadi	100	0	100	0	0	0
Overall	85.71	14.29	65.36	20.36	0.00	14.29

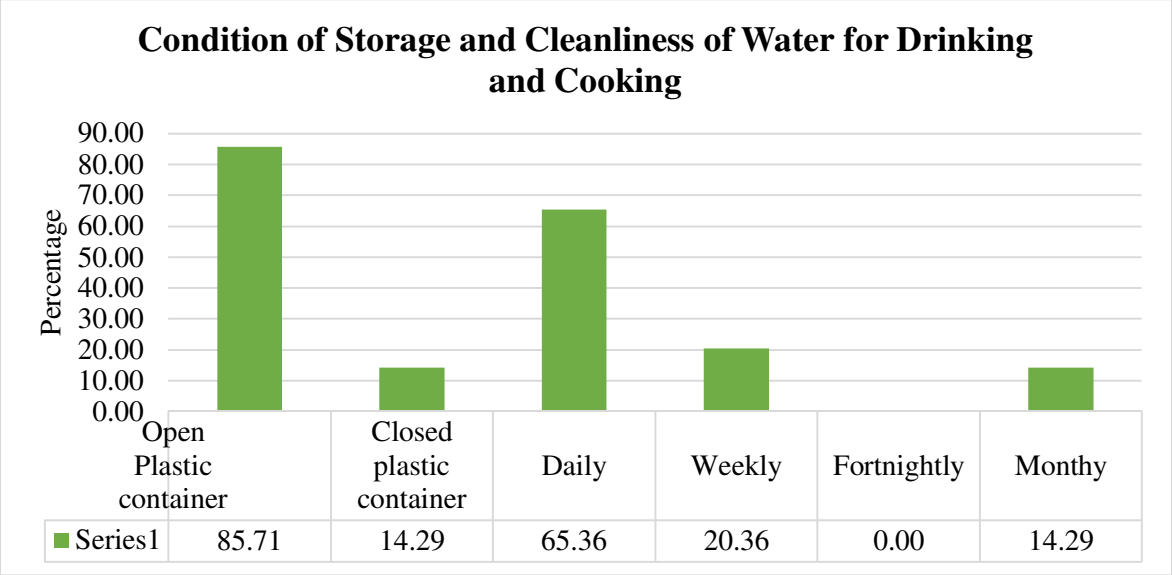

Fig. 7 Condition of Storage and Cleanliness of Water for Drinking and Cooking

G. Condition and Status of Personal Hygiene

Table 7 sheds light on the condition and status of personal hygiene among slum dwellers in Aligarh City, providing critical insights into their access to handwashing facilities and personal hygiene practices, particularly for children. The data reveals that many slums enjoy a high level of access to handwashing facilities within their homes, with slums such as Sarai Rehman, Nagla Ashiq Ali, Junglegadi, Makdoom Nagar, Roravar Ashik, Sonpal Nagar, Ramnagar, Chuharpur, Nagla Molvi, and Manzoorgadi achieving 100% coverage. However, other slums exhibit a varying degree of access, such as Dori Nagar (80%), Lakshimpur (80%), Nagla Masani (80%), and Zakir Nagar (80%), while areas like Bhagwan Nagar and Jalalpur lag behind, with 40% of households lacking access. The absence of handwashing facilities in these households reflects significant infrastructure gaps and poses a heightened risk of hygiene-related health issues.

When analyzing hygiene practices for children, the data reveals an uneven landscape. Regular bathing for children is reported to be a standard practice in certain slums like Sarai Rehman, Ramnagar, and Chuharpur, where 100% of households ensure consistent bathing. Other slums such as Junglegadi (80%), Sonpal Nagar (80%), Shahanshabad (80%), and Manzoorgadi (80%) also display commendable efforts. However, slums such as Sarai Gadi (30%), Nagla Mehtab (30%), and Alambagh Bhamola (50%) show significantly lower rates, suggesting either a lack of awareness or limited resources for maintaining hygiene standards.

The practice of handwashing before meals appears to be an area requiring serious improvement. Many slums report low levels of compliance, with only a minority of households, such as those in Sarai Gadi (70%) and Nagla Mehtab (70%), emphasizing this crucial practice. Slums like Ramnagar, Chuharpur, Bhagwan Nagar, and Bihari Nagar report no households ensuring handwashing before meals, reflecting a critical gap in hygiene behavior. This practice is particularly important for preventing the spread of waterborne diseases, and its neglect underscores the need for targeted awareness campaigns in these communities.

Clean clothing for children, another essential aspect of personal hygiene, is notably absent across all surveyed slums. None of the households in any slum reported maintaining clean clothing for children as a standard practice, indicating severe socio-economic constraints that prevent families from affording adequate clothing or ensuring its cleanliness. This lack of clean clothing exacerbates the health vulnerabilities of children, particularly in densely populated and unsanitary living conditions.

Overall, the findings from Table 7 highlight both progress and persistent challenges in personal hygiene among slum dwellers in Aligarh City. While access to handwashing facilities in many slums is relatively high, there remains a considerable gap in adopting key hygiene practices such as handwashing before meals, regular bathing, and maintaining clean clothing for children. These findings emphasize the need for integrated interventions, including infrastructure development to provide basic amenities, community-level education campaigns to promote hygiene awareness, and policy measures aimed at addressing the socio-economic barriers that hinder access to hygiene resources. Addressing these challenges holistically will be critical in improving the overall health and well-being of slum communities in Aligarh City.

Table 7: Condition and Status of Personal Hygiene(Figures in Percentage)

Slum	Access to handwashing facilities inside the house		Manage personal hygiene for children in house		
	Yes	No	Regular bathing	Handwashing before meals	Clean clothing
Sarai Rehman	100	0	100	0	0
Dori nagar	80	20	60	40	0
Hanumanpuri	70	30	40	60	0
Bhagwan Nagar	60	40	60	0	0
Bihari Nagar	70	30	70	0	0
Sarai Gadi	60	40	60	0	0
Nagla Ashiq Ali	100	0	70	30	0
Junglegadi	100	0	80	20	0
Makdoom Nagar	100	0	50	50	0
Roravar Ashik	100	0	60	40	0
Ladiya	100	0	70	30	0
Sonpal Nagar	100	0	80	20	0
Ramnagar	100	0	100	0	0
Chuharpur	100	0	100	0	0
Lakshimpur	80	20	40	60	0
Sarai Gadi	100	0	30	70	0
Alambagh Bhamola	70	30	50	50	0
Nagla Masani	80	20	60	40	0
Nagla Mehtab	70	30	30	70	0
Kunjalpur	70	30	60	40	0
Nagla Molvi	100	0	70	305	0
Shahanshabad	80	20	80	20	0
Jiwangarh	70	30	60	40	0
Zakir Nagar	80	20	80	20	0
Nagla Mansingh	100	0	60	40	0
Elampur	100	0	50	50	0
Jalalpur	60	40	60	40	0
Manzoorgadi	100	0	80	20	0
Overall	85.71	14.29	64.64	41.25	0.00

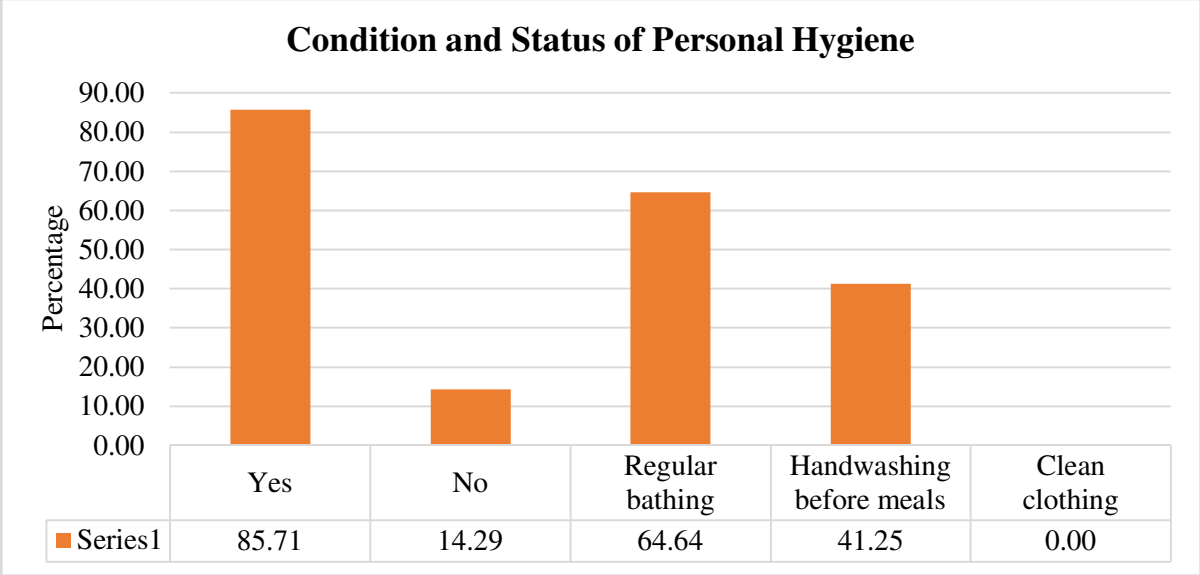

Fig. 8 Condition and Status of Personal Hygiene

H. Bathroom and Sanitation Conditions

Table 8 highlights the bathroom and sanitation conditions of slum dwellers in Aligarh City, showcasing disparities in access to toilet facilities, their location, and the type of infrastructure used. The data reveals that many slums have made significant progress in providing toilet facilities within households. Slums such as Sarai Rehman, Makdoom Nagar, Ladiya, Sonpal Nagar, Chuharpur, Lakshimpur, Alambagh Bhamola, and Shahanshabad report 90% of households having toilet facilities in their homes. Similarly, a notable percentage of households in slums like Dori Nagar (80%), Nagla Ashiq Ali (80%), Roravar Ashik (80%), and Junglegadi (70%) also have access to in-house toilets. However, certain slums such as Bhagwan Nagar (20%), Bihari Nagar (40%), and Nagla Mansingh (40%) remain underprivileged, with a significant portion of households lacking basic toilet facilities, reflecting the dire need for improved sanitation infrastructure in these areas.

The location of toilet facilities also plays a critical role in assessing sanitation accessibility. Many slums exhibit a high percentage of households with toilets within their premises, such as Sarai Rehman, Ladiya, Sonpal Nagar, and Chuharpur, all reporting 100% coverage. Other slums like Dori Nagar, Nagla Ashiq Ali, and Elampur demonstrate considerable access, with 80–90% of households having facilities on-site. In contrast, Bhagwan Nagar, Bihari Nagar, and Jalalpur lag behind, with only 20–60% of households reporting toilets within premises, underscoring the pressing need to bridge these gaps to ensure basic hygiene and convenience for residents.

The type of toilet infrastructure further emphasizes the disparities across slums. Flush toilets are predominantly used in slums with better access to sanitation, including Sarai Rehman, Ladiya, Sonpal Nagar, Ramnagar, and Chuharpur, where 100% of households with toilets have flush systems. Other areas, such as Dori Nagar, Junglegadi, and Nagla Ashiq Ali, also show significant adoption of flush toilets, with 70–90% of households equipped with such facilities. However, slums like Bhagwan Nagar, Bihari Nagar, and Nagla Mansingh rely heavily on makeshift latrines, with 60–80% of households resorting to these inadequate and often unsanitary alternatives. This stark contrast highlights the socio-economic challenges that limit access to modern sanitation infrastructure in certain areas.

Overall, the findings in Table 8 underscore the varied state of sanitation among slum dwellers in Aligarh City, with significant strides in some slums contrasted by severe deficiencies in others. While many slums have achieved commendable progress in ensuring access to in-house toilets with flush systems, others still grapple with inadequate or absent facilities, reflecting persistent inequalities. The reliance on makeshift latrines in certain slums underscores the urgent need for targeted interventions, including infrastructure development, awareness campaigns about hygiene and sanitation, and policy measures to improve access to affordable and sustainable sanitation solutions. Addressing these issues is critical not only for improving living conditions but also for enhancing public health and ensuring the dignity of slum residents in Aligarh City.

Table 8: Bathroom and Sanitation Conditions(Figures in Percentage)

Slum	Toilet facility in the house		Within premises		Kind of toilet	
	Yes	No	Yes	No	Flush	Makshift Latrines
Sarai Rehman	90	10	100	0	100	0
Dori nagar	80	20	80	20	80	20
Hanumanpuri	70	30	70	30	70	30
Bhagwan Nagar	20	80	20	80	20	80
Bihari Nagar	40	60	40	60	40	60
Sarai Gadi	60	40	60	40	60	40
Nagla Ashiq Ali	80	20	80	20	80	20
Junglegadi	70	30	70	30	70	30
Makdoom Nagar	90	10	90	10	90	10
Roravar Ashik	80	20	70	30	70	30
Ladiya	90	10	100	0	100	0
Sonpal Nagar	90	10	100	0	100	0
Ramnagar	80	20	100	0	100	0
Chuharpur	90	10	100	0	100	0
Lakshimpur	90	10	90	10	90	10
Sarai Gadi	70	30	70	30	70	30
Alambagh Bhamola	90	10	90	10	90	10
Nagla Masani	80	20	80	20	80	20
Nagla Mehtab	80	20	70	30	70	30
Kunjalpur	60	40	80	20	80	20
Nagla Molvi	80	20	80	20	80	20
Shahanshabad	90	10	90	10	90	10
Jiwangarh	80	20	80	20	80	20
Zakir Nagar	80	20	80	20	80	20
Nagla Mansingh	40	60	40	60	40	60
Elampur	80	20	90	10	90	10
Jalalpur	60	40	60	40	60	40
Manzoorgadi	90	10	90	10	90	10
Overall	75.00	25.00	77.50	22.50	77.50	22.50

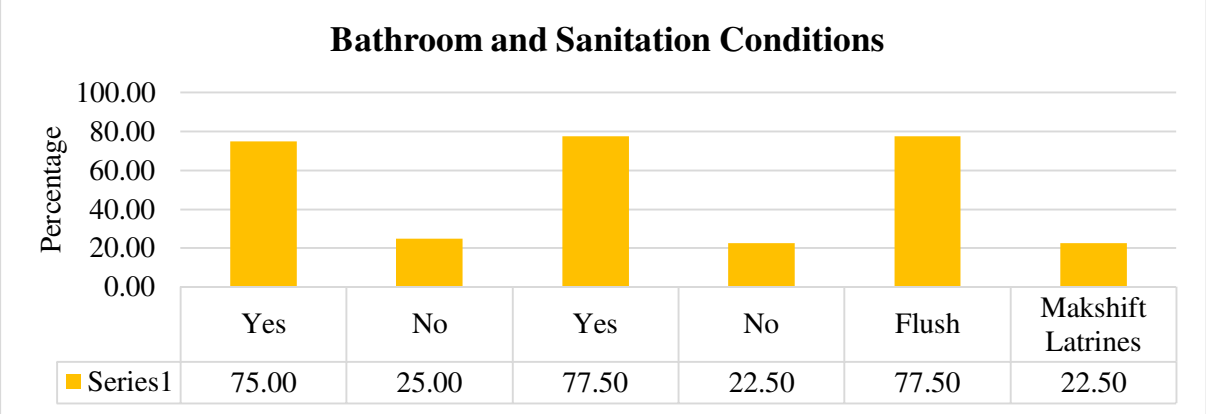

Fig. 9 Bathroom and Sanitation Conditions

I. Problems from the Toilet

Table 9 highlights the problems related to toilet use among slum dwellers in Aligarh City, emphasizing issues such as the disposal of fecal matter, soap usage at toilets, and other sanitation-related challenges like the prevalence of flies, mosquitoes, and foul smells. The data reveals that the disposal of fecal matter is predominantly managed through open drains across many slums. In slums such as Bihari Nagar, Junglegadi, Ladiya, Lakshimpur, Nagla Mehtab, and Manzoorgadi, 90% of households rely on open drains for waste disposal, reflecting inadequate sanitation infrastructure. Meanwhile, a smaller proportion of households in these areas, ranging between 10–40%, resort to open fields, showcasing a significant gap in access to hygienic toilet facilities. On the other hand, slums such as Sarai Rehman, Bhagwan Nagar, and Roravar Ashik show relatively balanced reliance on open drains and fields, with figures like 60% and 40%, respectively.

Soap usage at toilets, a critical factor for maintaining personal and communal hygiene, shows a promising trend in certain slums, but disparities remain. In slums like Sarai Rehman, Nagla Ashiq Ali, Junglegadi, Roravar Ashik, Sonpal Nagar, Chuharpur, Lakshimpur, Nagla Mansingh, and Manzoorgadi, 100% of households report using soap at toilets, highlighting strong hygiene practices. However, in areas such as Bhagwan Nagar, Makdoom Nagar, Nagla Mehtab, and Alambagh Bhamola, only 60–70% of households use soap, leaving a significant percentage without proper hygiene measures, which could lead to increased health risks.

Other problems associated with toilet use include the prevalence of flies, mosquitoes, and foul smells, which affect the living environment and health of slum residents. Slums like Manzoorgadi, Nagla Masani, Elampur, and Jiwangarh report high incidences of flies and mosquitoes, with figures reaching up to 90%. This indicates poor waste management and sanitation infrastructure, contributing to a breeding ground for vectors that can spread diseases. Similarly, slums such as Bhagwan Nagar, Sarai Rehman, Sonpal Nagar, and Lakshimpur are more affected by foul smells, with 60% or more of households reporting this issue.

While certain slums demonstrate better hygiene practices and infrastructure, the overall scenario reflects the pressing need for improved sanitation solutions. The reliance on open drains for waste disposal, limited soap usage, and persistent sanitation problems like vector prevalence and foul odors underscore the need for targeted interventions. These include the construction of proper drainage systems, awareness campaigns to promote soap usage, and measures to address sanitation-related nuisances. Enhancing the sanitation facilities in these slums would not only improve the quality of life but also contribute to better public health outcomes, highlighting the importance of addressing these critical issues in Aligarh City's slum areas.

Table 9: Problems from the Toilet(Figures in Percentage)

	Disposal of faecal matter from manual toilet		Use ofsoap at the toilet		Other problem from the latrine	
Slum	Open Drains	In the fields	Yes	No	Flies/mosquitos	Foul smell
Sarai Rehman	60	40	100	0	40	60
Dori nagar	80	20	80	20	80	20
Hanumanpuri	70	30	70	30	70	30
Bhagwan Nagar	60	40	60	40	40	80
Bihari Nagar	90	10	70	30	40	60
Sarai Gadi	80	20	60	40	60	40
Nagla Ashiq Ali	70	30	100	0	70	30
Junglegadi	90	10	100	0	60	40
Makdoom Nagar	70	30	70	30	50	50
Roravar Ashik	60	40	100	0	70	30
Ladiya	90	10	100	0	60	40
Sonpal Nagar	60	40	100	0	40	60
Ramnagar	80	20	100	0	50	50
Chuharpur	70	30	100	0	70	30
Lakshimpur	90	110	100	0	40	60
Sarai Gadi	80	20	100	0	70	30
Alambagh Bhamola	60	40	70	30	60	40

Nagla Masani	70	30	80	20	80	20
Nagla Mehtab	90	10	70	30	70	30
Kunjalpur	60	40	70	30	50	50
Nagla Molvi	80	20	100	0	60	40
Shahanshabad	60	40	80	20	70	30
Jiwangarh	90	10	70	30	80	20
Zakir Nagar	70	30	80	20	70	30
Nagla Mansingh	80	20	100	0	60	40
Elampur	70	30	100	0	80	20
Jalalpur	60	40	60	40	60	40
Manzoorgadi	90	10	100	0	90	10
Overall	74.29	29.29	85.36	14.64	62.14	38.57

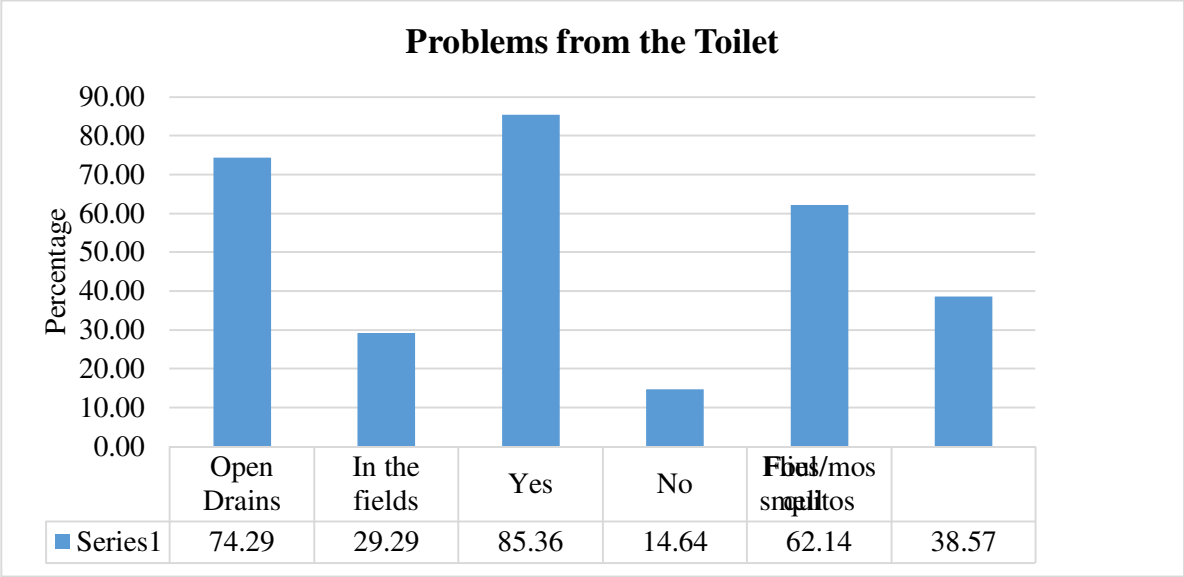

Fig. 10 Problems from the Toilet

J. Availability of Bathing Facilities and its Conditions

Table 10 provides an in-depth analysis of the availability, ventilation, and condition of bathing facilities across various slums in Aligarh City, showcasing significant disparities in infrastructure and hygiene conditions. The data reveals that the availability of attached bathrooms and toilets varies widely, with slums like Sarai Rehman, Makdoom Nagar, Alambagh Bhamola, Elampur, and Manzoorgadi showing high levels of accessibility, where 90-100% of households have attached facilities. Conversely, slums such as Bhagwan Nagar, Bihari Nagar, Nagla Mehtab, and Nagla Mansingh exhibit lower availability, with 40-60% of households relying on bathing enclosures without roofs, indicating inadequate infrastructure and poor living conditions.

Ventilation, an essential aspect of maintaining hygiene and reducing the buildup of dampness, also shows stark differences. Slums such as Sarai Rehman, Junglegadi, Lakshimpur, and Kunjalpur report higher percentages of households (70-80%) with window ventilation in bathrooms, reflecting better air circulation. On the other hand, slums like Bhagwan Nagar, Bihari Nagar, and Nagla Masani reveal that 60-90% of households lack proper ventilation, relying on enclosed spaces with no windows, leading to compromised air quality and increased susceptibility to mold and dampness. Such poor ventilation conditions contribute to unhealthy living environments and elevate the risks of respiratory issues and other health problems. The presence of dampness and mold, critical indicators of unhygienic and unsafe conditions, also varies significantly. Bhagwan Nagar, Hanumanpuri, and Zakir Nagar report high levels of dampness and mold, with 70-90% of households experiencing these issues. These findings highlight serious maintenance and structural challenges in these slums, reflecting prolonged exposure to water leakage and inadequate drainage systems. In contrast, slums like Sarai Rehman, Roravar Ashik, and Jalalpur show a better scenario, with 70-90% of households reporting no dampness or mold, indicative of relatively better construction quality and maintenance practices.

The data paints a picture of inequality in the availability and condition of bathing facilities in the slums of Aligarh City. While some slums demonstrate better access to attached bathrooms, proper ventilation, and absence of dampness, others remain plagued by insufficient facilities, poor ventilation, and unhealthy conditions due to mold and dampness. These disparities underscore the urgent need for targeted interventions to improve the overall sanitation infrastructure in slums. Investments in constructing well-ventilated bathrooms, addressing dampness through proper drainage systems, and ensuring equitable access to hygienic bathing facilities can significantly enhance the living conditions of slum dwellers. Furthermore, community awareness programs on the importance of hygiene and the maintenance of bathing facilities could empower residents to take proactive measures to mitigate these challenges. Addressing these issues is essential for improving public health, reducing health risks, and promoting a better quality of life for slum residents in Aligarh City.

Table 10: Avaiulability of Bathing Facilities and its Conditions(Figures in Percentage)

	Availability of bathing facility		Ventilation in the bathroom/toilet		Dampness and mold in the bathroom	
Slum	Bathroom and toilet attached	Bathing in enclosure without roof	Window	No ventilation	Present	Not Present
Sarai Rehman	100	0	80	20	30	70
Dori nagar	90	10	60	40	50	50
Hanumanpuri	80	20	40	60	80	20
Bhagwan Nagar	20	80	10	90	90	10
Bihari Nagar	40	60	30	70	60	40
Sarai Gadi	60	40	30	70	40	60
Nagla Ashiq Ali	80	20	60	40	70	30
Junglegadi	70	30	80	20	30	70
Makdoom Nagar	90	10	30	70	60	40
Roravar Ashik	70	30	60	40	30	70
Ladiya	40	60	40	60	60	40
Sonpal Nagar	50	50	30	70	70	30
Ramnagar	70	30	40	60	60	40
Chuharpur	80	20	60	40	40	60
Lakshimpur	90	10	70	30	30	70
Sarai Gadi	70	30	80	20	10	90
Alambagh Bhamola	90	10	40	60	60	40
Nagla Masani	80	20	30	70	70	30
Nagla Mehtab	40	60	80	20	20	80
Kunjalpur	60	40	80	20	40	60
Nagla Molvi	70	30	70	20	30	70
Shahanshabad	90	10	60	40	40	60
Jiwangarh	80	20	60	40	40	60
Zakir Nagar	80	20	20	80	80	20
Nagla Mansingh	40	60	40	60	70	30
Elampur	90	10	40	60	50	50
Jalalpur	60	40	70	30	10	90
Manzoorgadi	90	10	40	60	30	70
Overall	70.36	29.64	51.07	48.57	48.21	51.79

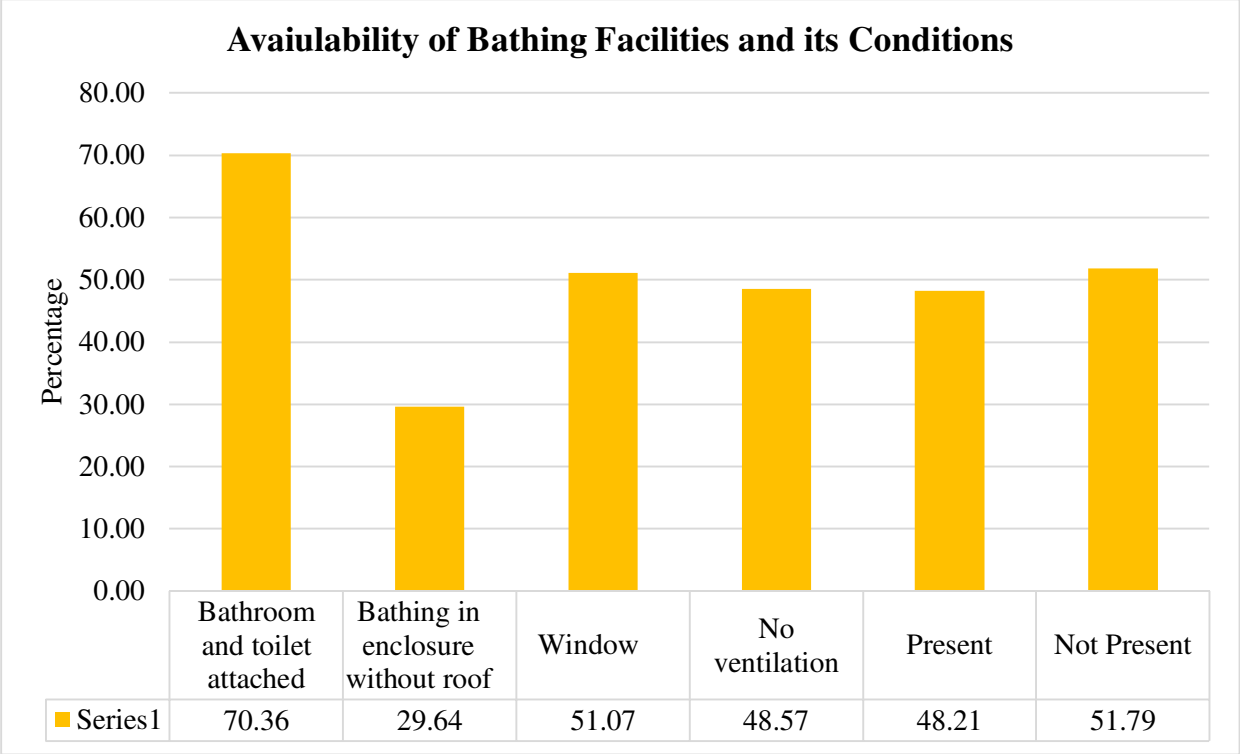

Fig. 11 Availability of Bathing Facilities and its Conditions

K. Sullage and Drainage of Waters

The table presents data on the sullage and drainage systems in various slums of Aligarh city, focusing on sewer connection, sullage disposal methods, and wastewater management. In all the slums listed, none of the households are connected to a formal sewer system, with 100% of the slum populations relying on alternative methods for waste disposal. In terms of sullage disposal, the majority of households (ranging from 60% to 100%) dispose of waste water into open drains, a practice that is prevalent in all the slums, indicating a lack of proper infrastructure for sewage management.

A smaller proportion of households dispose of waste water around the house, with figures varying from 0% to 80%, and no significant trend can be observed based on locality. Furthermore, the majority of households (100%) channel their waste water into the main drain, indicating a form of central drainage system, though it is likely to be informal and not connected to an organized sewage treatment system. Specific slums, such as Sarai Rehman and Dori Nagar, report 70% and 90% of waste water being disposed of in open drains, respectively, while others like Makdoom Nagar and Alambagh Bhamola have higher percentages of water being disposed of around the house.

This inconsistent pattern reflects the variability in how different areas cope with waste water disposal. For example, slums like Hanumanpuri and Bhagwan Nagar have a complete reliance on open drains, with no water being disposed of around the house. In contrast, slums like Alambagh Bhamola and Manzoorgadi show a more diverse approach, with significant portions of households resorting to the problematic practice of water disposal around homes. Overall, the table underscores the absence of a structured sewage system in these areas and highlights the reliance on informal and potentially hazardous methods for waste water management.

It also suggests a pressing need for urban planning and infrastructure development, especially in slum areas, to address the public health and environmental risks posed by inadequate drainage and sullage disposal systems. The dominance of open drain systems across all slums further reinforces the poor sanitation conditions and the urgent need for comprehensive waste management solutions in Aligarh's slum settlements.

Table 11: Sullage and drainage of waters(Figures in Percentage)

Slum	Sewer connection		Sullage disposal		Waste water
	Yes	No	Into the open drain	Around the house	Into the main drain
Sarai Rehman	0	100	70	30	100
Dori nagar	0	100	90	10	100
Hanumanpuri	0	100	100	0	100
Bhagwan Nagar	0	100	100	0	100
Bihari Nagar	0	100	80	20	100
Sarai Gadi	0	100	70	30	100
Nagla Ashiq Ali	0	100	100	0	100
Junglegadi	0	100	100	0	100
Makdoom Nagar	0	100	60	40	100
Roravar Ashik	0	100	100	0	100
Ladiya	0	100	100	0	100
Sonpal Nagar	0	100	100	0	100
Ramnagar	0	100	70	30	100
Chuharpur	0	100	100	0	100
Lakshimpur	0	100	100	0	100
Sarai Gadi	0	100	40	60	100
Alambagh Bhamola	0	100	20	80	100
Nagla Masani	0	100	100	0	100
Nagla Mehtab	0	100	60	40	100
Kunjalpur	0	100	100	0	100
Nagla Molvi	0	100	40	60	100
Shahanshabad	0	100	100	0	100
Jiwangarh	0	100	40	60	100
Zakir Nagar	0	100	100	0	100
Nagla Mansingh	0	100	30	70	100
Elampur	0	100	40	60	100
Jalalpur	0	100	90	10	100
Manzoorgadi	0	100	30	70	100
Overall	0.00	100.00	76.07	23.93	100.00

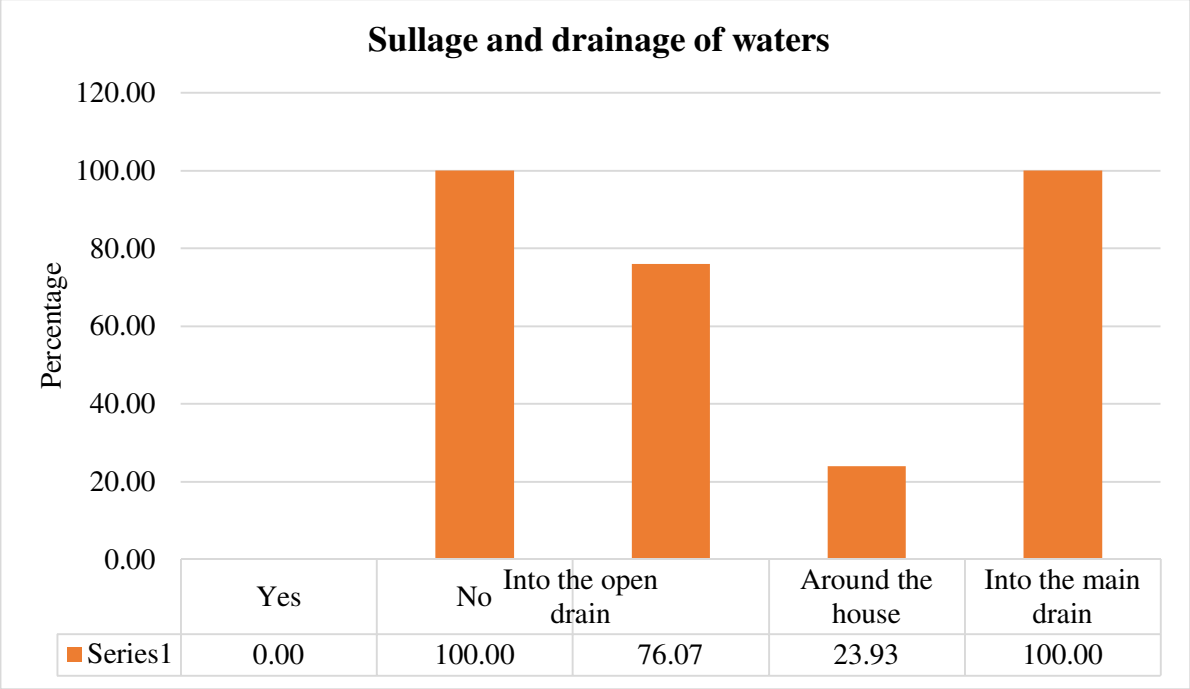

Fig. 12 Sullage and drainage of waters

L. Condition of Ventilations and Indoor Pollution

Table 12 presents data on the condition of ventilation and indoor air pollution issues in various slums of Aligarh, highlighting how poor housing conditions exacerbate health risks due to inadequate ventilation and the presence of indoor pollutants. The table indicates that natural ventilation methods, including doors and open spaces, are more common than window ventilation in most slums, with significant variation across the areas.

For example, in slums like Sarai Rehman, Dori Nagar, and Bihari Nagar, a majority of households (60%-80%) rely on natural ventilation, while others like Sonpal Nagar and Makdoom Nagar report as low as 10%-20% of households using windows for ventilation. This imbalance suggests a reliance on informal and often inefficient methods of ventilating homes, which can lead to poor indoor air quality.

Regarding indoor air pollution, the majority of households in most slums report facing indoor pollution issues. Hanumanpuri, Bhagwan Nagar, and Nagla Ashiq Ali, for example, show 60%-90% of residents experiencing indoor air pollution, a clear indication of unhealthy living conditions. Only a small portion of households (10%-40%) in some slums, like Bhagwan Nagar and Alambagh Bhamola, report no indoor pollution issues, suggesting that these areas may have slightly better ventilation or environmental conditions. Measures to control indoor pollution are reported across all slums, but they vary widely in effectiveness. The most common measure taken is avoiding smoking indoors, with figures ranging from 50% to 100% across the slums. For instance, in Zakir Nagar and Jiwangarh, 100% of households take this precaution, while in other slums like Sarai Rehman and Dori Nagar, only 30%-70% of households adopt this practice.

Proper ventilation, though a critical measure, is less commonly implemented, with only 20%-60% of households across most slums reporting that they have sufficient ventilation to combat indoor pollution. These figures further emphasize the inadequate infrastructure and lack of awareness in managing indoor environmental health risks. The data shows that slums with better natural ventilation systems (e.g., Sarai Gadi, Makdoom Nagar) tend to report fewer problems with indoor air pollution, though the effectiveness of such measures is still limited. This lack of effective control measures exacerbates health issues like respiratory problems and allergies among slum dwellers. Overall, the table highlights the severe indoor air quality challenges faced by slum populations in Aligarh and underscores the urgent need for improved housing conditions, better ventilation systems, and more effective pollution control measures to mitigate these environmental health risks.

Table 12: Condition of ventilations and indoor pollution(Figures in Percentage)

Slum	Ventilation in house		Face indoor air pollution issues		Measures take to control indoor pollution	
	Windows	Natural ventilation (e.g., doors, open spaces)	Yes	No	Proper ventilation	Avoiding smoking indoors
Sarai Rehman	80	20	20	80	30	70
Dori nagar	60	40	40	60	30	70
Hanumanpuri	30	70	60	40	40	60
Bhagwan Nagar	60	40	90	10	60	40
Bihari Nagar	20	80	70	30	40	60
Sarai Gadi	30	70	70	30	30	70
Nagla Ashiq Ali	40	60	30	70	20	80
Junglegadi	60	40	40	60	40	60
Makdoom Nagar	20	80	70	30	30	70
Roravar Ashik	60	40	40	60	40	60
Ladiya	20	80	60	40	30	70
Sonpal Nagar	10	90	70	30	40	60
Ramnagar	30	70	60	40	30	70
Chuharpur	40	60	40	60	20	80
Lakshimpur	40	60	30	70	30	70
Sarai Gadi	70	30	20	80	10	90
Alambagh Bhamola	30	70	60	40	20	80
Nagla Masani	40	60	70	30	30	70
Nagla Mehtab	70	30	20	80	20	80
Kunjalpur	60	40	20	80	20	80
Nagla Molvi	50	50	20	70	10	90
Shahanshabad	30	70	40	60	20	80
Jiwangarh	20	80	40	60	10	90
Zakir Nagar	40	60	80	20	0	100
Nagla Mansingh	10	90	70	30	40	60
Elampur	30	70	60	40	60	40
Jalalpur	70	30	30	70	50	50
Manzoorgadi	30	70	20	80	40	60
Overall	41.07	58.93	47.86	51.79	30.00	70.00

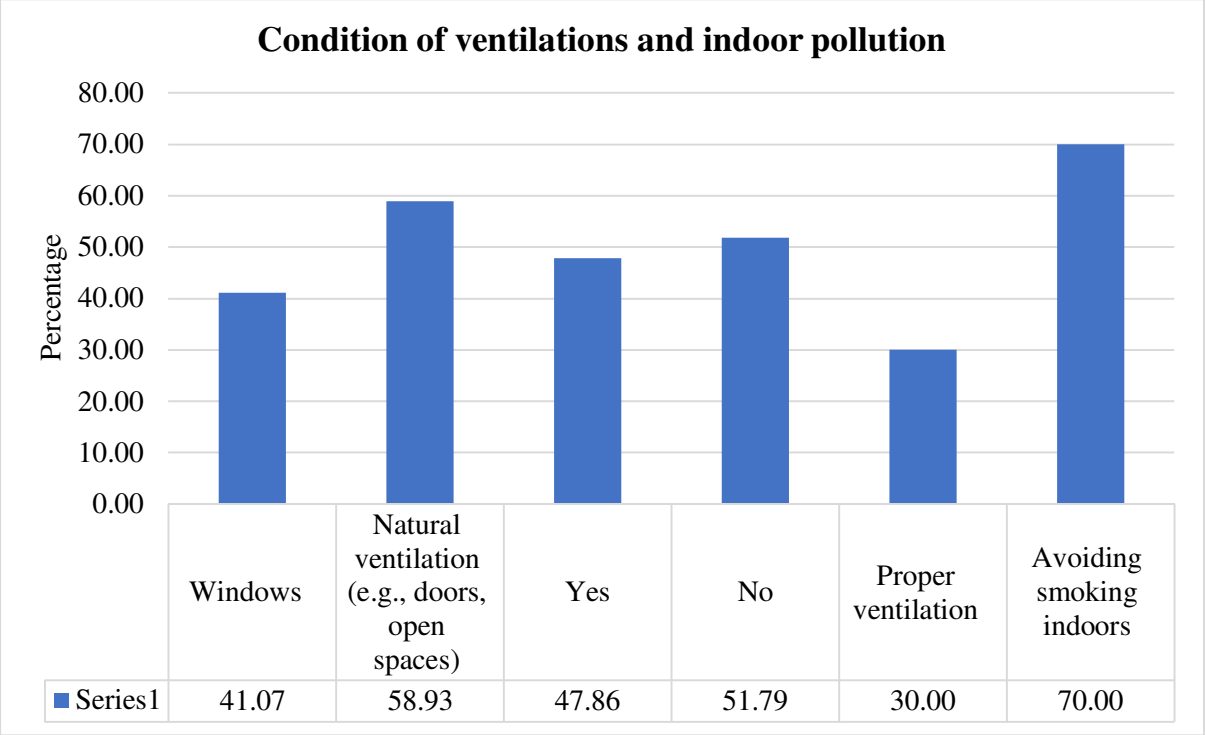

Fig. 13 Condition of ventilations and indoor pollution

M. Other Problems related to Indoor Environment

Table 13 provides an overview of the various indoor environmental issues faced by slum dwellers in Aligarh, focusing on moisture or dampness, pest or insect problems, and the measures taken to address these issues. The data reveals a widespread presence of indoor moisture and dampness, with the highest percentage observed in slums like Bhagwan Nagar, Makdoom Nagar, and Manzoorgadi, where 70%-90% of households report experiencing moisture problems. This suggests a significant issue with inadequate housing infrastructure, leading to poor indoor air quality and potential health risks such as mold growth and respiratory problems. In contrast, areas like Sarai Rehman and Dori Nagar report much lower levels of moisture problems, with only 20%-40% of households affected. Despite the high prevalence of moisture issues, all the slums in the table report that residents do not take any measures to deal with this problem, indicating a lack of effective solutions or resources for home maintenance.

Pest and insect issues are also prevalent across the slums, with no households reporting pest problems in the data. However, despite the absence of regular pest control measures, many households implement cleaning routines to maintain basic hygiene. Regular cleaning is reported as a measure for pest control, and the percentage of households engaging in this activity varies between 60% to 100%, depending on the slum. For instance, slums like Sarai Rehman, Dori Nagar, and Alambagh Bhamola report near-total cleaning routines, whereas others like Manzoorgadi report only 10%-30% of residents taking cleaning measures. This inconsistency highlights the varying levels of awareness and availability of cleaning facilities among slum dwellers.

Moreover, some slums like Hanumanpuri and Makdoom Nagar show a significant number of households (60%-90%) not taking any measures to control pests and insects, suggesting inadequate awareness or lack of access to resources such as pesticides or pest control services. Additionally, while the majority of households (70%-100%) report cleaning their homes regularly, the high number of slums reporting no measures to control pests or moisture issues reveals a gap in addressing the root causes of these problems.

The table also illustrates how slum dwellers, especially in more affected areas like Zakir Nagar, Ladiya, and Bihari Nagar, face a persistent challenge in maintaining a healthy indoor environment, despite daily cleaning efforts. The presence of moisture and pests, combined with the lack of measures to address them, further contributes to poor living conditions, which could have long-term health implications. This information underlines the urgent need for interventions to improve housing quality, access to pest control, and moisture management in Aligarh's slums. The data suggests that while cleaning is common, there is a clear lack of systemic solutions to combat the indoor environmental issues that contribute to deteriorating health and quality of life for slum dwellers.

Table 13: Other Problems related to Indoor Environment(Figures in Percentage)

	Moisture or dampness inside the house		Deal with moisture or dampness issues		Problems with pests or insects inside the house		Measures take to control pests and insects		Clean house daily	
Slum	Yes	No	Regular cleaning	No measures	Yes	No	Regular cleaning	No measures	Yes	No
Sarai Rehman	20	80	0	100	0	100	0	100	100	0
Dori nagar	40	60	0	100	0	100	0	100	80	20
Hanumanpuri	60	40	0	100	0	100	0	100	70	30
Bhagwan Nagar	90	70	0	100	0	100	0	100	20	80
Bihari Nagar	70	30	0	100	0	100	0	100	40	60
Sarai Gadi	70	30	0	100	0	100	0	100	60	40
Nagla Ashiq Ali	30	70	0	100	0	100	0	100	80	20
Junglegadi	40	60	0	100	0	100	0	100	70	30
Makdoom Nagar	70	30	0	100	0	100	0	100	90	10
Roravar Ashik	40	60	0	100	0	100	0	100	70	30
Ladiya	60	40	0	100	30	70	0	100	100	0
Sonpal Nagar	70	30	0	100	0	100	0	100	100	0
Ramnagar	60	40	0	100	10	90	0	100	100	0
Chuharpur	40	60	0	100	0	100	0	100	100	0
Lakshimpur	30	70	0	100	20	80	0	100	90	10
Sarai Gadi	20	80	0	100	10	90	0	100	70	30
Alambagh Bhamola	60	40	0	100	20	80	0	100	90	10
Nagla Masani	70	30	0	100	10	90	0	100	80	20
Nagla Mehtab	20	80	0	100	30	70	0	100	70	30
Kunjalpur	20	80	0	100	60	40	0	100	80	20
Nagla Molvi	20	80	0	100	0	100	0	100	80	20
Shahanshabad	40	60	0	100	0	100	0	100	90	10
Jiwangarh	40	60	0	100	0	100	0	100	80	20
Zakir Nagar	80	20	0	100	0	100	0	100	80	20
Nagla Mansingh	70	30	0	100	0	100	0	100	40	60
Elampur	60	40	0	100	0	100	0	100	90	10
Jalalpur	30	70	0	100	20	80	0	100	60	40
Manzoorgadi	80	20	0	100	60	40	0	0	90	10
Overall	50.00	52.14	0.00	100.00	9.64	90.36	0.00	96.43	77.50	22.50

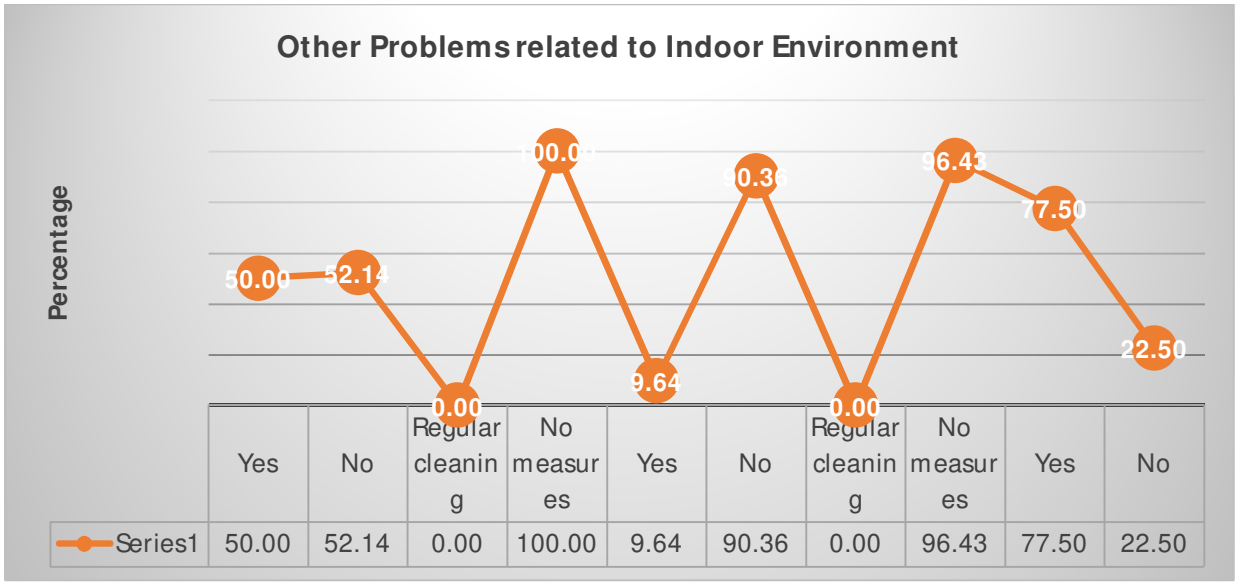

Fig. 14 Other Problems related to Indoor Environment

N. Availability of Household Assets

Table 14 presents data on the availability of household assets in various slums of Aligarh, highlighting the significant lack of basic household items and infrastructure among the residents. The table shows that the majority of households in the slums do not possess common assets such as televisions, radios, or heaters, indicating a lack of access to basic amenities that are often taken for granted in more developed urban areas. For instance, in slums like Sarai Rehman, Dori Nagar, Hanumanpuri, and Bhagwan Nagar, there is a complete absence of these household assets, reflecting the extreme poverty and deprivation faced by the residents. The availability of other assets, such as cycles, electric irons, and fans, is similarly sparse, with only a few slums reporting the presence of these items. For example, in Bihari Nagar and Nagla Ashiq Ali, around 30%-70% of households have a cycle, while in slums like Ramnagar and Lakshimpur, 70%-80% of households possess a fan, which is a basic comfort for dealing with the extreme heat in the region. However, despite the presence of some assets in certain slums, the overall availability remains minimal across the board, indicating that most slum dwellers live without essential items that contribute to daily comfort and productivity. The data also shows that there are no significant variations in the availability of assets across different slums, as most households in these areas are unable to afford or access even basic electrical appliances like fans, electric irons, or heaters. The lack of these assets contributes to the harsh living conditions of slum residents, who often have to rely on alternative means for heating, cooling, and daily chores. Additionally, very few slums report any other types of household assets, further highlighting the economic constraints of these communities. Only in a few slums, such as Jiwangarh, Zakir Nagar, and Manzoorgadi, do we see a higher proportion of households with access to some assets, like cycles and fans, but these are still far from universal. The overall picture that emerges from this table is one of severe socio-economic inequality, where a lack of basic household assets reflects the broader challenges of poverty, limited access to resources, and inadequate infrastructure that slum dwellers face in Aligarh. This scarcity of household goods exacerbates the vulnerability of slum dwellers, limiting their ability to improve their living standards and affecting their overall quality of life. The table underscores the pressing need for interventions that provide access to basic assets and improve the living conditions of slum residents in Aligarh.

Table 14: Availability of Household Assets(Figures in Percentage)

Slum	Television	Radio	Chauki	Cycle	Fan	Electric iron	Heater	Any other
Sarai Rehman	0	0	0	0	80	0	0	0
Dori nagar	0	0	0	0	0	0	0	0
Hanumanpuri	0	0	0	0	0	0	0	0
Bhagwan Nagar	0	0	0	0	0	0	0	0
Bihari Nagar	0	0	70	0	30	0	0	0

Sarai Gadi	0	0	0	0	0	0	0	0
Nagla Ashiq Ali	0	0	60	0	70	0	0	0
Junglegadi	0	0	70	0	0	0	0	0
Makdoom Nagar	0	0	30	0	50	0	0	0
Roravar Ashik	0	0	70	0	60	0	0	0
Ladiya	0	0	60	0	0	0	0	0
Sonpal Nagar	0	0	70	0	0	0	0	0
Ramnagar	0	0	80	0	0	0	0	0
Chuharpur	0	0	0	0	0	0	0	0
Lakshimpur	0	0	80	0	80	0	0	0
Alambagh Bhamola	0	0	70	30	70	0	0	0
Nagla Masani	0	0	60	40	0	0	0	0
Nagla Mehtab	0	0	80	60	0	0	0	0
Kunjalpur	0	0	70	30	0	0	0	0
Nagla Molvi	0	0	60	40	0	0	0	0
Shahanshabad	0	0	70	30	0	0	0	0
Jiwangarh	0	0	100	80	0	0	0	0
Zakir Nagar	0	0	100	70	0	0	0	0
Nagla Mansingh	0	0	30	0	0	0	0	0
Elampur	0	0	70	0	0	0	0	0
Jalalpur	0	0	70	30	80	0	0	0
Manzoorgadi	0	0	80	40	80	0	0	0
Overall	0.00	0.00	53.70	16.67	22.22	0.00	0.00	0.00

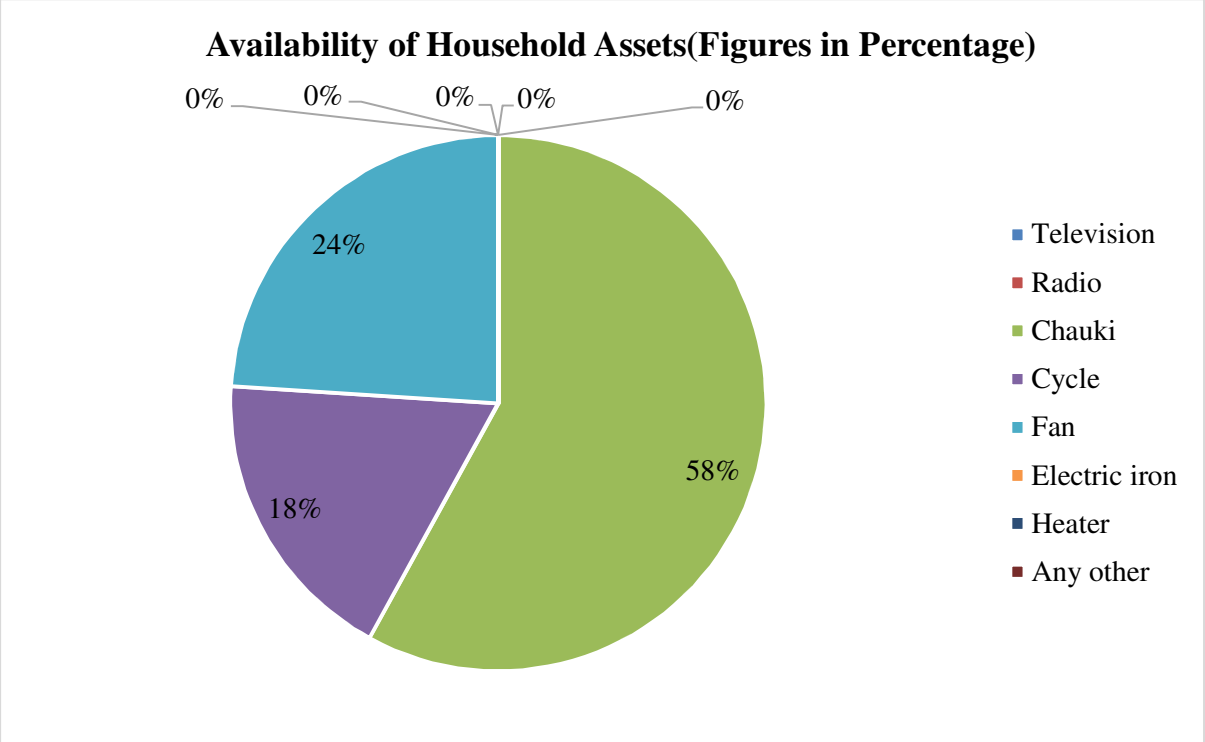

Fig. 15 Availability of Household Assets

VI. CONCLUSION

This study highlights the significant socio-economic and environmental challenges faced by slum dwellers in Aligarh City, emphasizing the interplay between indoor and outdoor environmental conditions. Poor infrastructure, overcrowding, inadequate access to basic amenities, and exposure to environmental hazards critically impact their health and well-being, as evident in the prevalence of respiratory and waterborne diseases. Addressing these issues necessitates targeted interventions in sanitation, ventilation, and waste management. The research underscores the transformative potential of urban policy frameworks like PMAY and AMRUT, which focus on infrastructure development but require deeper integration of community-specific needs. Tools such as ArcGIS have proven effective in mapping and identifying slum spots, enabling policymakers to prioritize interventions. Moreover, participatory planning processes involving slum dwellers are crucial for ensuring the sustainability and equity of these policies. The study advocates for a multidimensional approach, emphasizing collaboration among municipal bodies, urban planners, and NGOs to implement long-term solutions such as affordable housing, improved drainage systems, regular waste collection, and access to clean water. Capacity-building initiatives focusing on health awareness, hygiene, and environmental sustainability can further empower these communities. Aligning with international frameworks like the Sustainable Development Goals, this research highlights the need for comprehensive urban policies to mitigate vulnerabilities, address resource pressures, and promote inclusive urban development. Ultimately, bridging the socio-economic gap and fostering community resilience are essential for sustainable transformation and equitable living conditions for all urban residents.

VII. ACKNOWLEDGMENT

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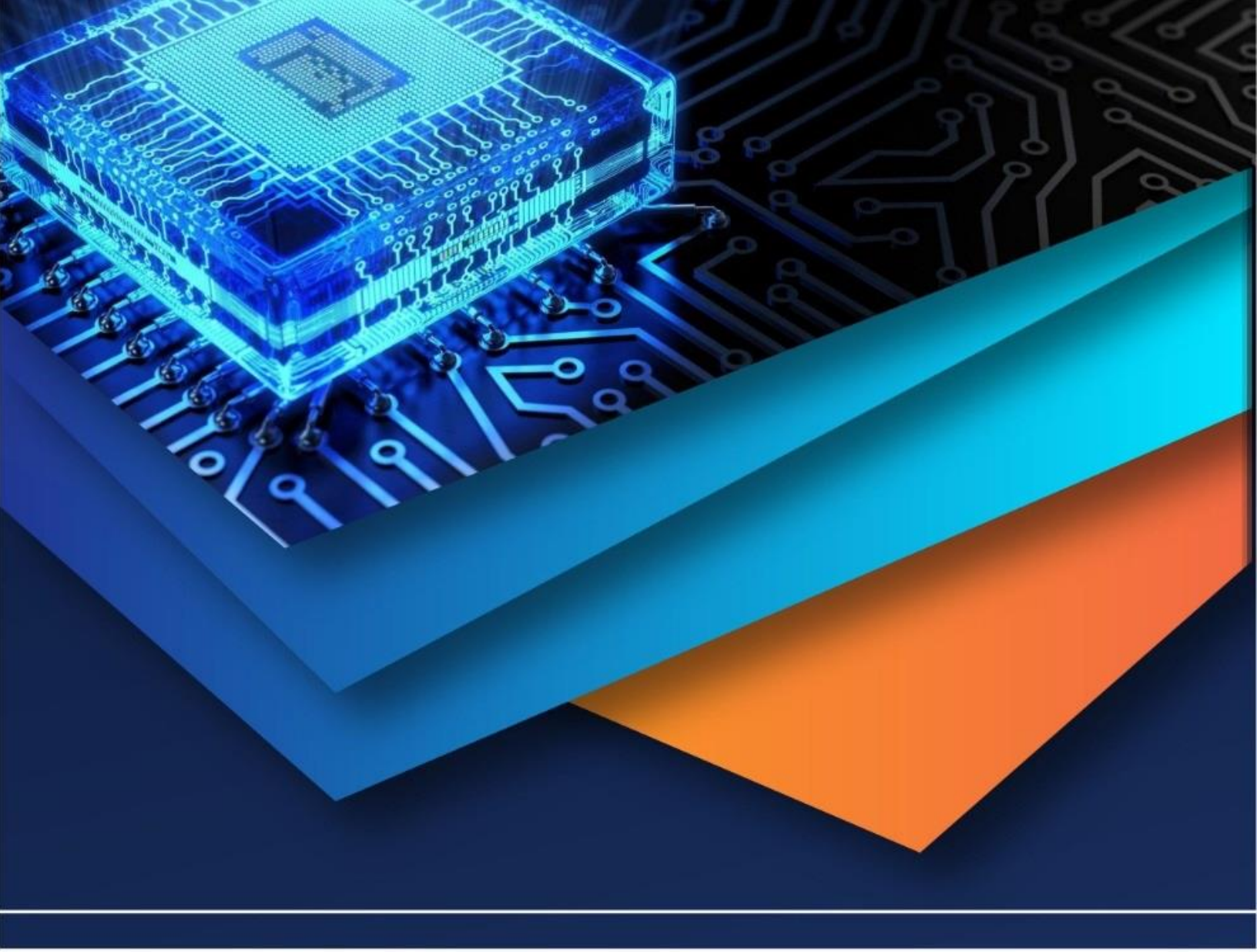

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