Assessing Water Quality and Its Impact on Human Health: A Study of Kanpur City, India

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ABSTRACT:
A critical factor that impacts public health, particularly in urban and industrial areas, is the purity of water. This study examines the physical, chemical, and microbiological parameters of the water in Zone-5 of Kanpur City, India, with a focus on their impact on human health. Using a cross-sectional approach, data was collected from 400 families through laboratory analysis and field surveys. The results suggest that water sources have been significantly contaminated, as evidenced by the presence of high concentrations of microbiological contaminants and heavy metals (chromium and arsenic). This contamination is predominantly the result of poor sanitation infrastructure and untreated industrial effluents. The health hazards associated with inadequate water quality were underscored by the fact that a substantial number of respondents reported experiencing waterborne diseases, such as typhoid, cholera, and hepatitis. A statistical analysis demonstrated a significant correlation between health outcomes and water quality, with educational attainment influencing awareness and preventive measures. The report underscores the urgent need for enhanced wastewater treatment facilities, community education initiatives, and more stringent regulatory enforcement to ensure access to clean and safe water. In order to address these challenges and safeguard the welfare of Kanpur's residents, it is recommended that multi stakeholder collaboration be implemented.

1. Introduction

Water is an essential resource for the maintenance of life and is essential for the advancement of human health, economic growth, and ecological balance [1]. However, the integrity of water resources has been gradually eroded as a result of the rapid industrialization and urbanization of cities [2]. Millions of individuals are directly impacted by water contamination, which has emerged as a critical global environmental concern [3]. Particularly in densely populated urban areas, inadequate treatment systems frequently lead to a variety of waterborne infections and persistent health issues, which are exacerbated by substandard water quality [4]. Urbanization and industrialization have a detrimental effect on water supplies, as evidenced by Kanpur, which is located in the northern Indian state of Uttar Pradesh. Kanpur, which is known as the "Manchester of the East" due to its thriving leather and textile industries, has faced substantial challenges in maintaining water quality, particularly in relation to the Ganga River and groundwater resources. Significant contamination of water bodies, including typhoid, cholera, and other waterborne maladies, has been caused by discharges from tanneries, untreated sewage, and inadequate waste management [5]. This has exposed the city's residents to health hazards. Poor water quality has health consequences that extend beyond acute illnesses, resulting in a decrease in the quality of life and an economic burden on families and communities [6]. Neurological abnormalities, developmental delays, and malignancies have been linked to prolonged exposure to contaminants in water, including arsenic, lead, and pesticides. Consequently, this is a multifaceted public health issue [7] [8].
The objective of this investigation is to evaluate the physical, chemical, and microbiological parameters of water quality in Kanpur and their potential impact on human health. The objective of this research is to integrate field surveys, laboratory investigation, and statistical evaluation to identify the primary causes of water pollution, quantify the prevalence of associated health consequences, and provide policymakers with actionable recommendations. The study underscores the urgent need for sustainable water management strategies and effective public health measures to ensure that Kanpur City residents have access to pure and safe water.

2. Literature Review

In environmental and public health research, the purity of water has consistently been a critical concern, as it has a direct impact on the well-being of the population and the stability of the regional ecosystem. In this section, the current research on water pollution, its origins, effects on human health, and mitigation techniques is analyzed, with a particular emphasis on the challenges that urban and industrial regions, such as Kanpur, India, face.

1.1 International Perspectives on Water Quality

Water pollution is a significant global issue, resulting in approximately 3.4 million fatalities annually due to waterborne diseases, including cholera, typhoid, and diarrhoea [9]. The degradation of water quality is a consequence of human activities, including industrial effluents and agricultural discharge, as evidenced by research [4]. Inequities in water resource management are underscored by research conducted in low- and middle-income nations, which indicates that approximately one-third of the population lacks access to safe potable water [10].

1.2 Water Pollution in Urban India

Water pollution is a pervasive issue in India, particularly in urban areas where the present water management systems have been overtaxed by rapid industrialization and population growth. Due to the discharge of untreated industrial effluents and sewage, the Ganga River is classified as one of the most contaminated water bodies by the Central Pollution Control Board (CPCB), particularly in urban areas like Kanpur [11]. Authors conducted a study that indicated the pervasive presence of microbiological pollutants, pesticides, and heavy metals in Indian water sources, which poses substantial health risks [12].

1.3 Adverse Health Effects of Poor Water Quality

The literature has extensively documented the correlation between public health and water quality. Neurological impairments, developmental issues, and numerous malignancies are associated with prolonged exposure to contaminants such as arsenic, lead, and nitrates in potable water [13]. Additionally, in regions with inadequate sanitation and hygiene practices, microbiological contamination from bacteria, viruses, and protozoa has been acknowledged as the primary cause of acute maladies, including cholera, hepatitis, and diarrhoea [14].

1.4 Examinations of Waterborne Diseases

Research conducted in Uttar Pradesh, notably in the vicinity of Kanpur, has revealed a substantial prevalence of waterborne infections, including typhoid, jaundice, and amoebic dysentery. Dr. Kumar found that regions that rely on untreated groundwater experienced an increase in the incidence of maladies, which was further exacerbated by a lack of awareness regarding water treatment techniques [15]. The financial burden of chronic disorders exacerbates the challenges, as families affected by these conditions frequently incur substantial out-of-pocket expenses for treatment [16].

1.5 Contributions of Urbanization and Industry to Water Pollution

The industrial operations of Kanpur, particularly in the leather and textile sectors, make a substantial contribution to river pollution. [17] conducted an investigation into the water quality of the Ganga River in the vicinity of Kanpur city. Their findings revealed that the river contains elevated levels of chromium and other heavy metals, which are linked to untreated tannery discharges. The situation is further exacerbated by the insufficient capacity of sewage treatment facilities, which are responsible for only a small portion of the city's effluent [18]. Furthermore, the Central Ground Water Board (CGWB) has conducted research that indicates that pesticide contamination from agricultural discharge is a contributing factor to groundwater pollution, which is a multifaceted issue.

1.6 Deficiencies and Policy Interventions

Water pollution in India is being addressed through initiatives such as the National Mission for Clean Ganga and the JalJeevan Mission, which aim to improve the quality and accessibility of water. However, a plethora of studies, including those conducted by the World Health Organization [19], argue that policy implementation is inconsistent, particularly in urban areas like Kanpur. The Bureau

of Indian Standards (BIS) has established water quality standards; however, the enforcement of these laws is frequently inadequate (BIS, 2020).
Despite the fact that the current literature provides a wealth of information regarding the effects of water pollution, there is a lack of localized research that investigates the correlation between public awareness, health consequences, and water quality in Kanpur. In order to develop sustainable solutions that are tailored to the unique socio-economic and environmental circumstances of the city, further research is necessary to integrate scientific data with community perceptions. The urgent need to address water contamination through interdisciplinary approaches that integrate environmental research, public health, and policy advocacy is emphasized by the literature that has been examined. The current study aims to address the deficiencies in understanding the specific issues that Kanpur faces and to propose practical solutions for improving water quality and protecting human health.

2. Approach

This study used a thorough methodology to evaluate water quality and its effects on human health in Kanpur City, India. The methodology integrates field surveys, laboratory analysis, and statistical evaluation to elucidate the current condition of water quality and its consequences for public health.

2.1 Research Locale

Kanpur, situated in Uttar Pradesh, is an industrial centre recognized for its leather and textile sectors, which substantially contribute to water pollution. The research examines Zone-5 of Kanpur, encompassing 19 wards with a population of 97,177 and 68,425 households. This region was chosen because of its significant industrial density and documented incidence of waterborne illnesses.

3. Methodology

The research employs a cross-sectional design executed in the post-monsoon season of 2022. This timeframe was selected because water contamination typically escalates during and following the monsoon season due to heightened runoff and drainage complications.

4. Data Acquisition

4.1 Principal Data

Primary data was obtained via field surveys and interviews. A semi-structured questionnaire was employed to collect data from families regarding:

- Demographic and socioeconomic profiles.
- Sources of potable water and water purification methods.
- Understanding and views of water quality.
- Health problems and documented watery illnesses.

The survey was segmented into five sections:

- Comprehensive demographic and socio-economic data.
- Sources, storage, and treatment methodologies for potable water.
- Understanding of aquatic illnesses and governmental initiatives.
- Health and sanitation protocols.
- Perspectives on water conservation and pollution reduction.

4.2 Secondary Data

Secondary data was obtained from:

- Documentation from the Central Pollution Control Board (CPCB) and the Central Ground Water Board (CGWB).
- Research publications regarding water quality and its health implications in India.
- Government publications, encompassing the National Health Profile and JalJeevan Mission reports.

4.3Sampling Methodology

A randomized selection method was employed to pick 400 houses from the 19 wards in Zone-5. The sample size was calculated with the formula:

$$n = \frac{Z^2 . p . q}{d^2}$$

where:

- $Z=1.96$ (95% confidence level), $p=0.785$ (percentage of households with access to potable water), $q=1-p$, $d=0.05$ (absolute precision).
- This resulted in a sample size of 393, which was rounded to 400 for enhanced representation.

4.4 Laboratory Examination

Water samples were obtained from primary sources, including city taps, hand pumps, and wells. The samples were examined for:

- Physical Parameters: pH, turbidity, and total dissolved solids (TDS).
- Chemical Parameters: Heavy metals (chromium, arsenic, lead), nitrates, and chlorides.
- Microbial Metrics: Coliform bacteria and other pathogens.
- Laboratory testing adhered to the standards set by the Bureau of Indian Standards (BIS) and the World Health Organization (WHO) on drinking water quality.

4.5 Data Examination

4.5.1 Explanatory Analysis

Frequencies, means, and standard deviations were computed for variables including water sources, treatment procedures, and health conditions.

4.5.2 Statistical Analyses

- Chi-Square Test: To analyze relationships between categorical variables such as knowledge of water quality and socio-economic determinants.
- Correlation Analysis: To evaluate the associations between water quality measures and documented health consequences.
- Regression Analysis: To ascertain predictors of waterborne diseases by the examination of water quality and demographic variables.

Software Data were analyzed utilizing SPSS version 20. Graphs and charts were generated in Microsoft Excel to enhance the visualization of results.

4.6 Ethical Considerations

- Participants were apprised of the study's aims and provided written consent.
- The confidentiality of personal information was guaranteed.
- The research complied with ethical standards sanctioned by pertinent institutional bodies.

4.7 Limitations

- The research is confined to Zone-5 of Kanpur, potentially lacking representation of the full city.
- Self-reported health information may be influenced by memory bias.
- Seasonal fluctuations in water quality were not entirely considered.

This analytical paradigm guarantees a thorough evaluation of water quality and its effects on public health, offering significant insights for policy and practice in urban water management.

5. Results

This study elucidates water quality issues in Kanpur's Zone-5 and its implications for public health. Below is a summary of data derived from household surveys, laboratory analyses, and statistical evaluations.

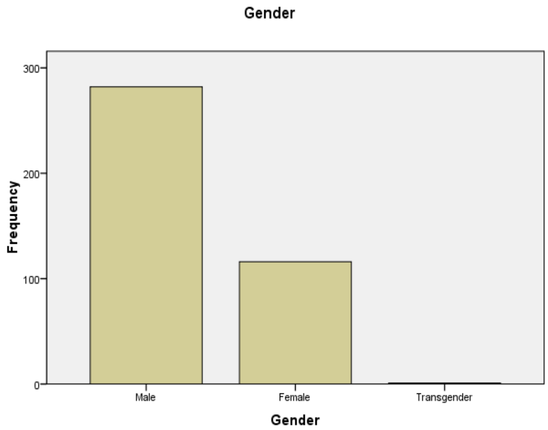
5.1 Respondent Demographics

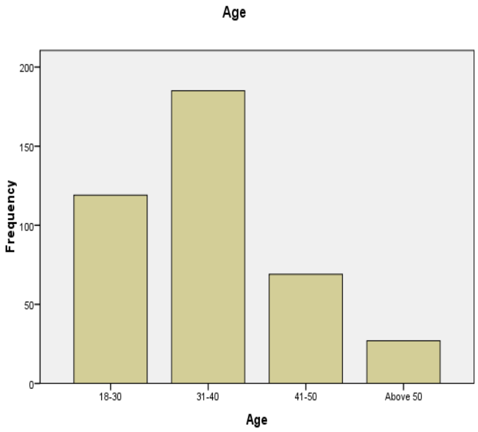
The demographic data emphasized the socio-economic diversity of the respondents:

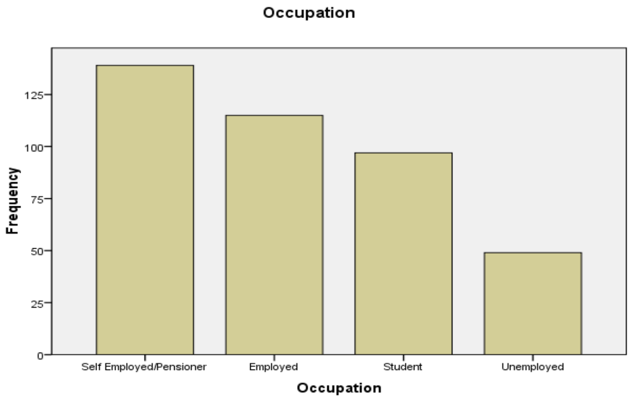
- Gender distribution: 69% male, 28% female, 0.25% transgender.
- Age: Primarily 31-40.
- Occupational distribution: 39.24% self-employed or pensioners, 28.33% employed, 23.89% students, 12.07% unemployed.
- Education: A majority (55.91%) have attained a high school diploma or its equivalent.

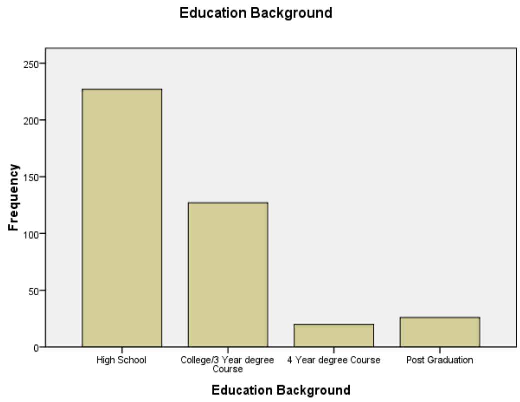
Table 1: Demographics of Respondents

		Frequency	Percentage
Residential Place	Gujaini	27	6.65
	Ravidaspuram	35	8.62
	Dabauli	28	6.90
	Kheedaspuram	2	0.49
	KaushalPuri	22	5.42
	Juhi	54	13.30
	Ratanlal Nagar	19	4.68
	Gautam	1	0.25
	FazalGanj	43	10.59
	Govind Nagar	60	14.78
	Barigav	1	0.25
	Nirala Nagar	57	14.04
	Panki	51	12.56
Gender	Male	282	69.46
	Female	116	28.57
	Transgender	1	0.25
Age	18-30	119	29.31
	31-40	185	45.57
	41-50	69	17.00
	Above 50	27	6.65
Occupation	Self Employed/Pensioner	139	34.24
	Employed	115	28.33
	Student	97	23.89
	Unemployed	49	12.07
Education Background	High School	227	55.91
	College/3 Year degree Course	127	31.28
	4 Year degree Course	20	4.93
	Post-Graduation	26	6.40









5.2 The data elucidates respondents' perspectives on solid waste management and water pollution:

- Solid Waste Management: Approximately 46.80% ranked it as Fair, 39.90% as Good, while a little percentage rated it Poor (3.94%) or Excellent (6.40%).
- Water Pollution: The majority of opinions were Moderate (48.03%) or Small (34.98%), with fewer replies indicating High (7.14%) or Least (4.93%).

Table 2: Opinions of Respondents on Certain Issues of the Localities

		Frequency	Percentage
Opinion about solid waste management	Poor	16	3.94
	Fair	190	46.80
	Good	162	39.90
	Excellent	26	6.40
	Don't Know	6	1.48
Opinion about water pollution	Least	20	4.93
	Small	142	34.98
	Moderate	195	48.03
	High	29	7.14
	Don't Know	13	3.20

- The bulk of respondents indicated closeness to River Bank/Urbanization (62.81%), followed by Industrial Land (15.02%), Agricultural Land (11.58%), and Wastewater Disposal Area (9.11%).
- Water Quality (Zone-5): Approximately 49.51% ranked it as Good, 32.76% as Fair, while fewer respondents classified it as Poor (4.43%) or Excellent (8.87%).
- A plurality (55.91%) expressed satisfaction with water quality, whereas 33.25% were dissatisfied, and 9.36% remained uncertain.
- Groundwater (Zone-5): The majority assessed it as Good (42.86%) or Fair (39.66%), with fewer evaluations for Poor (8.13%) or Excellent (5.67%).

Table 3: Opinions regarding the surrounding of the Respondents

		Frequency	Percentage
Exact Location	Next to Agricultural Land	47	11.58
	Next to River Bank/Urbanisation	255	62.81
	Next to an Industrial Land	61	15.02
	Next to waste water disposing area	37	9.11
Water quality (Zone-5)?	Poor	18	4.43
	Fair	133	32.76
	Good	201	49.51
	Excellent	36	8.87
	Don't Know	12	2.96
Satisfied with the water quality	Yes	227	55.91
	No	135	33.25
	Don't know	38	9.36
Ground water (Zone 5)?	Poor	33	8.13
	Fair	161	39.66
	Good	174	42.86
	Excellent	23	5.67
	Don't Know	9	2.22

5.3 Origins of Potable Water

- Drinking Water Source: Most respondents rely on Tap from Water Board (56.40%) or Community Water Scheme (27.59%), with fewer using Dug Well/Tube Well (11.33%) or Surface Water (3.20%).
- Water Safety Perception: Safety is primarily judged by the Environment around the water source (52.71%), followed by Water Quality Reports (25.12%) and Look, Taste, Smell (11.82%), with 8.87% unsure.
- Household Water Treatment Methods: Most respondents use Filtering/RO (63.55%), with fewer opting for Adding Chlorine (19.70%) or Boiling (10.34%), while 4.93% use no treatment.
- Quality of Drinking Water: Half rated it as Good (50.99%), followed by Fair (29.56%) and Excellent (11.58%), with minimal ratings for Poor (3.69%) or Don't Know (2.46%).

Table 4: Sources of Drinking Water and its Quality

		Frequency	Percentage
Drinking water come from	Dug Well/Tube Well	46	11.33
	Tap from Water Board	229	56.40
	Tap from community Water scheme	112	27.59
	Surface Water (River, stream, spring)	13	3.20
Water is safe for drinking add data	by look, taste, smell	48	11.82
	Water quality reports	102	25.12
	Environment around the water	214	52.71

	source		
	don't know	36	8.87
household water treatment methods	Boiling	42	10.34
	Filtering/RO	258	63.55
	Adding Chlorine	80	19.70
	No Treatment	20	4.93
quality of drinking water	Poor	15	3.69
	Fair	120	29.56
	Good	207	50.99
	Excellent	47	11.58
	Don't Know	10	2.46

5.4 The research underscores perceptions of dangers to water from multiple sources:

- Industrial or Factory Waste: The majority of respondents classified it as a Moderate Threat (56.40%) or a Somewhat Threat (26.85%), with merely 2.22% perceiving it as No Threat.
- Urban Runoff: The majority classified it as a Somewhat Threat (44.58%) or a Moderate Threat (28.82%), while fewer perceived it as No Threat (8.13%) or a Serious Threat (2.46%).
- The loss of natural areas was perceived as a Somewhat Threat by 48.28% of respondents, a Moderate Threat by 29.80%, while only 1.72% regarded it as No Threat and 5.67% as a Serious Threat.
- Community Sewage Treatment Plants and Septic Tanks: The majority of respondents perceived these as a Moderate Threat (52.71%) or a Somewhat Threat (32.02%), with negligible replies indicating No Threat (1.97%) or a Serious Threat (5.42%).

Table 5: Threat to Water Bodies

		Frequency	Percentage
Severity of threat posed to water [Industrial or factory waste]	No threat	9	2.22
	Not much of a threat	30	7.39
	Somewhat Threat	109	26.85
	Moderate Threat	229	56.40
	Serious threat	22	5.42
Severity of threat posed to water [Runoff from cities and towns]	No threat	33	8.13
	Not much of a threat	59	14.53
	Somewhat Threat	181	44.58
	Moderate Threat	117	28.82
	Serious threat	10	2.46
Severity of threat posed to water [Loss of natural areas]	No threat	7	1.72
	Not much of a threat	53	13.05
	Somewhat Threat	196	48.28
	Moderate Threat	121	29.80
	Serious threat	23	5.67
Severity of threat posed to water [Community sewage treatment plants & septic tanks]	No threat	8	1.97
	Not much of a threat	26	6.40
	Somewhat Threat	130	32.02
	Moderate Threat	214	52.71
	Serious threat	22	5.42

5.5 The data elucidates the community's perceptions of prospective hazards to water quality:

- A significant majority of respondents either Agree (62.32%) or Strongly Agree (4.93%) with the implementation of enhanced requirements for landowners to safeguard soil and water. A minor fraction of respondents disagreed (8.13%) or strongly disagreed (1.23%).
- Agricultural runoff is a threat: 58.87% of participants agree and 2.96% strongly agree that it endangers their drinking water, while 26.60% remain indifferent.
- A notable percentage of respondent's express concern regarding chemicals in their drinking water, with 58.13% agreeing and 9.36% strongly agreeing. Merely 3.94% express disagreement.

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- A notable percentage of respondent's express concern regarding chemicals in their drinking water, with 58.13% agreeing and 9.36% strongly agreeing. Merely 3.94% express disagreement.
- Water Contamination from Runoff Over Paved Areas: Opinions are polarised, with 28.57% in agreement and 8.37% in strong agreement that runoff over paved surfaces constitutes an issue, while 40.64% maintain a neutral stance. Significantly, 11.82% Strongly Disagree.

Table 6: Respondents Attitude towards threat to Water Quality

		Frequency	Percentage
attitudes toward potential threat to water quality [We need to increase regulations for landowners to protect soil and water]	Strongly disagree	5	1.23
	Disagree	33	8.13
	Neither agree nor disagree	88	21.67
	Agree	253	62.32
	Strongly Agree	20	4.93
attitudes toward potential threat to water quality [Runoff from agricultural crop production is a threat to my drinking water]	Strongly disagree	10	2.46
	Disagree	31	7.64
	Neither agree nor disagree	108	26.60
	Agree	239	58.87
	Strongly Agree	12	2.96
attitudes toward potential threat to water quality [I am concerned about chemicals in my drinking water]	Strongly disagree	5	1.23
	Disagree	16	3.94
	Neither agree nor disagree	105	25.86
	Agree	236	58.13
	Strongly Agree	38	9.36
attitudes toward potential threat to water quality [Water contamination from runoff over paved areas is a problem]	Strongly disagree	48	11.82
	Disagree	37	9.11
	Neither agree nor disagree	165	40.64
	Agree	116	28.57
	Strongly Agree	34	8.37

- The perception of climate change reveals that a majority exhibit scepticism about present forecasts, with 39.16% expressing "somewhat" doubt and 27.09% "knowingly" questioning their validity, while 16.75% remain uncertain.
- Bacterial Diseases: Typhoid, cholera, and various other bacterial infections exhibit a substantial correlation with inadequate water quality; however, 47.29% remain uncertain.
- Chemical Contaminants: Pesticides, lead, and arsenic are associated with significant health hazards, including cancer, neurological impairment, and developmental disorders, as evidenced by the substantial recognition of these correlations in "somewhat" and "know" replies (e.g., 56.16% for arsenic).
- Excessive fluoride and nitrate levels can lead to illnesses such as dental fluorosis, spinal injury, and "blue baby syndrome," however some ambiguity remains for many individuals.
- Heavy Metals and Petrochemicals: Extended exposure to benzene, chlorinated solvents, and other metals is associated with cancer, neurological damage, and metabolic disturbances, acknowledged by a considerable percentage.

Table 7: Impact on Water by Foreign Ingredients

linkage between poor water quality and diseases		Frequency	Percentage
Bacterial infections (typhoid/ cholera/ paratyphoid fever/ bacillary dysentery)	Somewhat - Think it is not	47	11.58
	Know - Think it is not	20	4.93
	Not sure	192	47.29
	Somewhat - Think it is	137	33.74
	Know - Think it is	4	0.99
Lead (central nervous system/ high risk for children and pregnant women)	Somewhat - Think it is not	9	2.22
	Know - Think it is not	36	8.87
	Not sure	143	35.22
	Somewhat - Think it is	175	43.10
	Know - Think it is	37	9.11
Excess fluorides (yellow teeth/ damage spinal cord)	Somewhat - Think it is not	7	1.72
	Know - Think it is not	34	8.37
	Not sure	183	45.07
	Somewhat - Think it is	140	34.48
	Know - Think it is	36	8.87
Nitrates (cause blue baby syndrome/ digestive tract cancers)	Somewhat - Think it is not	26	6.40
	Know - Think it is not	100	24.63
	Not sure	118	29.06
	Somewhat - Think it is	123	30.30
	Know - Think it is	33	8.13
Chlorinated solvents (Cause reproduction disorder/ cancer cause)	Somewhat - Think it is not	15	3.69
	Know - Think it is not	30	7.39
	Not sure	121	29.80
	Somewhat - Think it is	197	48.52
	Know - Think it is	37	9.11
Other heavy metals (Damage nervous system/ damage kidneys/ metabolic disruptions)	Somewhat - Think it is not	10	2.46
	Know - Think it is not	22	5.42
	Not sure	149	36.70
	Somewhat - Think it is	187	46.06
	Know - Think it is	28	6.90

5.7 The data offers insights into community perceptions regarding activities that affect water quality and fertiliser application on agricultural properties.

- Significant Adverse Impacts on Water Quality: Urbanization/Development: Recognised by the majority (32.02%) as exerting the greatest substantial adverse effect on water quality. Urban Wastewater/Sewerage: The second most significant issue, identified by 23.40%. Irregular Solid Waste Dumps: Identified as a significant factor in water deterioration, accounting for 19.21%. Industrial Pollution: Acknowledged by 12.07% of participants.
- Pesticide and Fertiliser Pollution: Documented at 11.58%, indicating its perceived contribution to water quality problems. Categories of Fertilisers Utilised in Agricultural Fields: Organic Fertilisers: A significant proportion (44.33%) indicates the utilisation of organic fertilisers. Integration of Organic and Conventional: A notable percentage (37.93%) utilises both types of fertilisers. Conventional Fertilisers: Merely 13.05% depend exclusively on conventional techniques. Uncertainty: A little proportion (3.20%) is uncertain on the type of fertiliser utilised.

Table 8: Negative Impact on Water Bodies through Activities

		Frequency	Percentage
activity have the greatest negative effect on water quality	Urbanisation/Development	130	32.02
	Urban waste water/sewerage	95	23.40
	Industrial Pollution	49	12.07
	Irregular Solid Waste Dumps	78	19.21
	Pesticide and Fertilizer Pollution	47	11.58
Types of fertilizer applied in agricultural lands	Conventional	53	13.05
	Organic	180	44.33
	Both Organic & Conventional	154	37.93
	Don't Know	13	3.20

- A significant portion (64.04%) indicates exposure to information regarding water quality, and primarily from conservation organisations (50.25%), followed by governmental bodies (27.34%), and less commonly via newspapers (13.79%) or the internet (7.14%).
- Prevalent techniques encompass the utilisation of water conservation devices (45.81%), limiting garden irrigation to morning and evening hours (22.17%), and implementing rainwater gathering systems (19.70%). Rain barrels are utilised infrequently (10.84%).
- More over half (53.94%) utilise water provided by the water board for gardening, whilst lesser percentages employ it for vehicle washing (12.56%), outdoor cleaning (20.20%), or the regular replenishment of pots (11.82%).
- Practices encompass the secure application and disposal of pesticides/herbicides (52.22%), eco-friendly cleaning agents (13.55%), and appropriate disposal of solid and liquid waste (26.11%). Merely 6.65% indicate utilising car wash facilities to reduce runoff.

Table 9: Water Conservation Practices

		Frequency	Percentage
seeing, hearing, or reading information about water quality	Yes	260	64.04
	No	100	24.63
	Don't know	40	9.85
Information sources used for retrieving information about water quality and conservation.	Internet	29	7.14
	Government Agencies	111	27.34
	Conservation Groups	204	50.25
	News Paper	56	13.79
Do you practice any of the following water conservation measures in your home?	Rain barrels	44	10.84
	Rain Water Harvesting System	80	19.70
	Water Conservation Devices	186	45.81
	Restricting Garden Water to AM and PM	90	22.17

Do you use 'Water board supplied water' for following?	Washing Vehicles	51	12.56
	Gardening	219	53.94
	In front of outdoors	82	20.20
	Regular empty pots and fill fresh water	48	11.82
Are you practicing effective measure to reduce water pollution in your area?	Use of environmentally friendly cleaning products	55	13.55
	Safe use and disposal of pesticides/herbicides	212	52.22
	Safe disposal of solid and liquid waste	106	26.11
	Use of car wash facilities	27	6.65

The data offers insights into public opinions regarding water quality monitoring systems and the assignment of responsibilities for enhancing water quality. Principal observations encompass:

- Surface/River Water: The majority of respondents regard monitoring as moderately important (57.39%) or important (26.60%), while a minimal number find it insignificant (0.74%).
- A substantial percentage of citizens (43.10%) perceive that individuals bear considerable duty, whereas 35.96% attribute them with fairly complete responsibility.
- Central/State Governments: Governments are predominantly perceived as fairly accountable (49.51%), with 26.11% assigning them a somewhat comprehensive duty.

Table 10: Water Quality Monitoring System

		Frequency	Percentage
Water quality monitoring system. [Surface Water/ River water]	Unimportant	3	0.74
	Little important	49	12.07
	Moderately Important	233	57.39
	Important	108	26.60
	Very Important	7	1.72
Attribution of responsibility for working to improve water quality. [Citizens]	Not at all responsible	28	6.90
	Somewhat responsible	25	6.16
	Moderate Responsible	175	43.10
	Somewhat completely responsible	146	35.96
	Completely Responsible	25	6.16
Attribution of responsibility for working to improve water quality. [Central/ State government]	Not at all responsible	14	3.45
	Somewhat responsible	33	8.13
	Moderate Responsible	201	49.51
	Somewhat completely responsible	106	26.11
	Completely Responsible	45	11.08

The data indicates perceptions on the duties of various groups in safeguarding water quality and the public's readiness to adopt behaviours for enhancement. Essential elements comprise:

- More over half (53.20%) are "definitely" inclined to alter behaviours to enhance water quality, whilst 30.30% are "probably" inclined. Merely 11.82% are "definitely not" inclined, while 2.96% remain ambivalent.

Table 11: Responsibilities for Water Bodies Protection

		Frequency	Percentage
Willingness to adopt or change one behaviour to improve water quality in their community.	Definitely	216	53.20
	Probably	123	30.30
	Definitely not	48	11.82
	May or may not	12	2.96

Statistical Examination

- Chi-Square Test: Significant correlation ($p<0.05$) between educational attainment and awareness of waterborne illnesses.

Analysis of Regression:

- Water quality characteristics were significant predictors of the occurrence of waterborne illnesses ($R^2 = 0.68$).

Laboratory Results

Laboratory examination of water samples disclosed:

- Physical Parameters: pH varied between 7.33 and 8.16, signifying slightly alkaline water.
- Chemical Contaminants: Elevated concentrations of chromium, arsenic, and nitrates in multiple samples beyond BIS thresholds.
- Microbial Contamination: Coliform bacteria detected in 63% of examined samples.

6. Discussion

This study's findings indicate substantial issues related to water quality and its effects on public health in Kanpur's Zone-5. These issues stem from industrial, municipal, and agricultural practices, exacerbated by insufficient infrastructure and a lack of public knowledge. This section examines significant results within the framework of current literature and the socio-economic setting of the studied region.

6.1 Water Quality and Sources

The dependence of 57.25% of surveyed homes on municipal water supply highlights the essential requirement for its quality to adhere to safety standards. Laboratory examination, however, indicated contamination by heavy metals, including chromium and arsenic, as well as microbiological contaminants. These pollutants presumably stem from unregulated industrial effluents and inadequately managed water treatment plants, as indicated in previous research [17]. The detection of coliform bacteria in 63% of water samples corresponds with research from metropolitan areas lacking sufficient sanitation facilities [11]. Public Perception and Cognizance Public assessments of water quality indicate significant worry, with 51.5% of respondents anticipating more decline in the following decade. Despite a moderate to high knowledge of waterborne infections within the population, hardly a small fraction (4.5%) employed modern treatment techniques such as reverse osmosis. This disparity underscores a disjunction between awareness and implementable actions, maybe attributable to budgetary limitations or inadequate access to economical alternatives.

6.2 Effects on Health

The research demonstrated a significant association between inadequate water quality and the incidence of waterborne illnesses, including typhoid, cholera, and hepatitis. These findings align with [20] [21], who highlighted the significance of microbial and chemical exposure in contributing to acute and chronic health issues. Prolonged exposure to heavy metals has been associated with neurological problems and developmental delays, especially in susceptible groups such as children, see table 7.

6.3 Infrastructure and Policy Gaps

Kanpur's water treatment system was determined to be markedly insufficient, treating merely a small portion of the generated effluent. Government initiatives like as the JalJeevan Mission seek to rectify these deficiencies; nevertheless, their execution in industrial areas like Zone-5 is inadequate. Moreover, initiatives like the National Mission for Clean Ganga aim at river restoration, yet their effectiveness is constrained by ongoing industry non-compliance and insufficient enforcement measures.

6.4 Statistical Analysis

The notable correlation between educational attainment and awareness of waterborne infections highlights the necessity of public education initiatives in reducing health risks. Regression analysis emphasized the predictive significance of water quality factors in influencing health outcomes, underscoring the necessity for comprehensive monitoring systems.

7. Conclusion

The research indicates that water quality in Kanpur's Zone-5 poses a significant public health issue, exacerbated by industrial pollution, insufficient waste management, and poor infrastructure. The subsequent points encapsulate the findings:

- Sources of Contamination: Industrial effluents, especially from the leather and textile industries, significantly contribute to chromium and arsenic pollution.
- Microbial contaminants from untreated sewage increase the deterioration of water quality.
- Health Implications: A significant incidence of waterborne infections is directly associated with contaminated water sources.
- Prolonged exposure to heavy metals presents enduring health hazards, encompassing neurological and developmental issues.

Challenges in Infrastructure:

- Current water treatment facilities function at inadequate capacities, resulting in a substantial volume of wastewater remaining untreated.
- Municipal water systems inadequately mitigate contaminants before distribution.
- Public Awareness and Behavior: Despite considerable awareness of water quality issues, the implementation of preventive measures such as water treatment is minimal.
- Policy Deficiencies: Notwithstanding statutory frameworks, the enforcement of pollution control measures in industrial zones is inadequate.
- Government interventions have not yet realized significant enhancements in urban water quality.

Recommendations

To mitigate these concerns, the subsequent measures are advised:

- Enhance Regulatory Enforcement: Guarantee rigorous adherence to industrial effluent regulations by consistent monitoring and sanctions for infractions.
- Augment Infrastructure: Increase wastewater treatment capacity and upgrade municipal water systems.
- Public Awareness Initiatives: Inform communities on the health consequences of polluted water and advocate for cost-effective water purification techniques.
- Promote public-private partnerships to finance and execute sustainable water management strategies.
- By prioritizing these interventions, officials can alleviate the detrimental effects of water pollution, protect public health, and promote the sustainable development of Kanpur.

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