DISSERTATION TRAINING

AT

INTERNATIONAL INSTITUTE OF HEALTH MANAGEMENT AND RESEARCH, NEW DELHI

Assessment of Heavy Metals in Drinking Water in Various Locations of the National Capital Region, Delhi, India

BY

RAHUL PRAKASH

PG/22/085

UNDER THE GUIDANCE OF

Dr. RATIKA SAMTANI

PGDM (Hospital & Health Management)

2022-24

International Institute of Health Management and Research, New Delhi

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(Completion of Dissertation)

The certificate is awarded to

Mr. Rahul Prakash

in recognition of having successfully completed his/her Internship in the department of

Public health

and has successfully completed his/her Project on

Assessment of heavy metals in drinking water in various location of the Nation capital region

29TH July 2024

IIHMR DELHI

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The Candidate has successfully carried out the study designated to him during internship training and his/her approach to the study has been sincere, scientific and analytical.

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Dr. Sumesh Kumar
Associate Dean, Academic and Student Affairs
IIHMR, New Delhi

Mentor

IIHMR, New Delhi

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The following dissertation titled **"Assessment of heavy metal in Drinking water in Delhi, India"** at **"IIHMR Delhi "** is hereby approved as a certified study in management carried out and presented in a manner satisfactorily to warrant its acceptance as a prerequisite for the award of **PGDM (Hospital & Health Management)** for which it has been submitted. It is understood thatby this approval the undersigned do not necessarily endorse or approve any statement made, opinion expressed or conclusion drawn therein but approve the dissertation only for the purpose it is submitted.

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Name	Signature
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Dr Nidhi Yadav	
Dr. Aman Raj Gupta	

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This is to certify that **Mr. Rahul Prakash,** a graduate student of the **PGDM (Hospital & Health Management)** has worked under our guidance and supervision.
He/ She is submitting this dissertation titled
" **Assessment of heavy metals in drinking water in various location of the Nation capital region**" at

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CERTIFICATE BY SCHOLAR

This is to certify that the dissertation titled ..Assessment of Heavy metals in Drinking water in various locations of the National Capital Region.. and submitted by (Name) ...Rahul prakash.....
.... Enrollment No. ....PG/22/085...............
under the supervision of ......Dr. Ratika Samtani..........................

for award of PGDM (Hospital & Health Management) of the Institute carried out duringthe period from .20/3/2024.... to ...20/6/2024.........
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FEEDBACK FORM

Name of the Student: Rahul prakash

Name of the Organisation in Which Dissertation Has Been Completed:

Area of Dissertation: Public Health.

Attendance: 99%

Objectives achieved: Yes

Deliverables: Fieldwork, Data collection, Analysis done systematically.

Strengths: Research driven,

Suggestions for Improvement:

Suggestions for Institute (course curriculum, industry interaction, placement, alumni):

Signature of the Officer-in-Charge/ Organisation Mentor (Dissertation)
Date:
Place:

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Name of Student (in block letter)	Dr/Mr./Ms.: Rahul prakash		
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Name of Guide/Supervisor	Dr/ Prof.: Dr. Ratika Samtani		
Title of the Dissertation/Summer Assignment	Assessment of heavy metals in Drinking water in various locations of the National Capital Region, Delhi, India.		
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OVERVIEW ABOUT THE ORGANIZATION

The International Institute of Health management Research, New Delhi was setup in the year

2008. The institute mainly provides post graduate programs in health, hospital and

information technology in health care and management development programs. The institute

also focus on the research projects which help in policy analysis, policy formulation and also

help in the implementation of the policies for the health care sectors. It has emerged as a

reputed institute for providing good health care management professionals nationally as well

as globally. It is an autonomous institute performing well for several years to improve health

care by training the students and making them good professionals for future. The institute

also made an effort to promote the success for the 17 sustainable Development Goals. The

IIHMR is involved in various research projects which act as a support for health policy and

planning.

MISSION AND VISSION OF IIHMR:

o **MISSION:** this institution is dedicated in the improvement of standards of health through proper and better management of health care and its programs with the help of management research, training, education and proper networking of the institute at global level

o **VISION:** the main objective and vision of the institute is to give its contribution in health care sector for social equity with the help of its commitment to support health programs for improving healthcare sectors

CAPABILITIES AND THRUST AREAS:

▪ AICTE approved two-year PGDHM

▪ Management development programs

▪ Research projects

▪ Quality assurance and accreditation

▪ Insurance related to healthcare

▪ E-learning

CORE ACTIVITIES:

▪ Research

▪ Training

▪ Teaching

GLOBAL NETWORKING:

IIHMR, Delhi has collaborations with various reputed institutions and organizations. Some of them are given below:

▪ World Health Organization (WHO)

▪ Southeast Asia Public Education Institution Network (SEAPHEIN)

▪ National Institute of Health and Family Welfare (NIHFW)

▪ SAARC Tuberculosis and HIV/AIDS Centre (STAC)

▪ National Health Systems Resource Centre (NHSRC)

▪ The Union South East Asia (USEA)

Abstract

Heavy metal poisoning of drinking water presents a serious concern to public health everywhere, especially in Delhi, India's National Capital Region (NCR). The purpose of this study is to evaluate the levels of heavy metals in drinking water in the NCR's several districts, including Dwarka, Sadatpur, Shahdra, and Mundka. Analysing drinking water samples for levels of arsenic (As), chromium (Cr), copper (Cu), cadmium (Cd), nickel (Ni), zinc (Zn), and lead (Pb), comparing the results to national and international standards, and determining any possible health risks related to these contaminants are the main goals.

41 water samples from various sources, including bottled water, municipal supplies, and bore wells, will be collected and analysed as part of a cross-sectional study that will take place between March and June of 2024. In order to collect sociodemographic and health information from the people, the study uses standardised questionnaires and optical emission spectroscopy to detect the amounts of heavy metals.

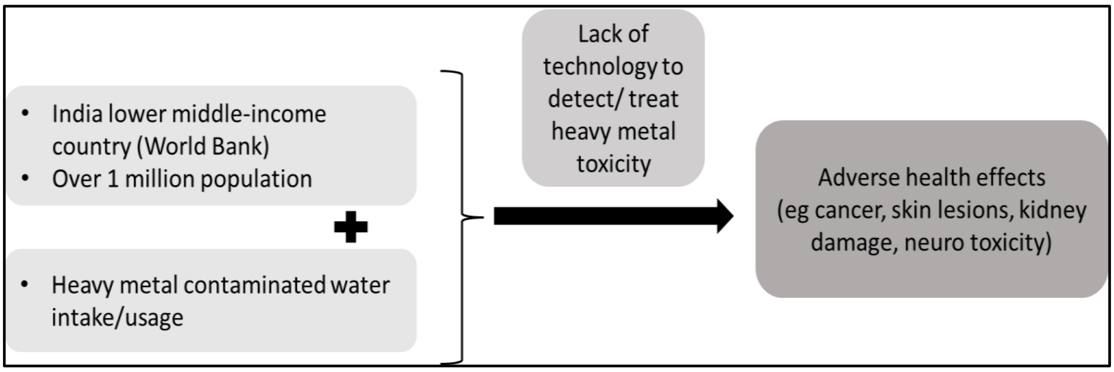
According to preliminary research, several heavy metals are found to be over allowable levels, which raises questions about potential long-term health consequences such as cancer, neurological impairment, cardiovascular disease, and kidney injury. This study emphasises how urgently strict monitoring and remediation activities are needed to guarantee that the public, especially in low-income communities, has access to clean drinking water. The findings will guide mitigation plans and policy suggestions to reduce heavy metal pollution in Delhi's drinking water, protecting the public's health in the process.

Table of contents

BACKGROUND

Introduction to the Research Problem With an estimated 1 billion people without access to clean drinking water (WHO, 2022) and 2 million casualties per year, water contamination is currently one of the world's leading causes of death (Gleick, 2003). Drinking water contamination with heavy metals is a persistent problem worldwide with grave public health consequences. A surge in energy production and an exponential increase in heavy metal use in industrial processes has led to a rise in human exposure to toxic heavy metals in recent decades (Tchounwou, 2012). Even in the current era of technological advancement, the concentration of heavy metals present in drinking water is still not within the recommended limits as set by the regulatory authorities in different countries of the world (Rehman, 2017). Drinking water contaminated with heavy metals namely Arsenic (As), Chromium (Cr), Copper (Cu), Cadmium (Cd), Nickel (Ni), Zinc (Zn), and Lead (Pb) is increasingly becoming a major health concern for public and health care professionals. These metals, which do not play any role in human homeostasis, induce multiple organ damage, cause birth defects, and are classified as carcinogens. (Tchounwou, 2012). Populations are exposed to heavy metals primarily through water consumption, and few heavy metals can also bioaccumulate in the human body (e.g., in lipids and the gastrointestinal system) and may induce cancer and other risks. Occupational exposure to heavy metals is also known to occur by the utilization of these metals in various industrial processes and/ or contents including color pigments and alloys. However, the predominant source resulting in measurable human exposure to heavy metals is the consumption of contaminated drinking water and the resulting health issues may include cardiovascular disorders, neuronal damage, renal injuries, and risk of cancer and diabetes.

The presence of heavy metals becomes even more problematic since most of the treatment plants in India are not equipped to detect or treat them.



Rationale of the Study Heavy metal contamination has not only impacted health and environment, but the crippling effect of its toxicity is metamorphosizing into a major public health issue today. For the past few years, there has been a concerning spike in the levels of heavy metals in our daily lives. The contamination of drinking water with these harmful heavy metals is one of the most serious issues, as no number of efforts so far have been able to rein in the growing levels of heavy metals in water. The major hazardous metals of concern for India in terms of their environmental load and health effects are lead, mercury, chromium, cadmium, copper, and aluminum. Their source is mostly anthropogenic — industrial activity and vehicles. Natural causes like seepage from rocks, volcanic activity and forest fires can also be the contributing factors. Considering the health effects, heavy metal toxicity can cause chronic degenerative diseases — the symptoms being mental disorders, pain in muscle and joints, gastro-intestinal disorders, vision problems, chronic fatigue, and susceptibility to fungal infections. Sometimes the symptoms are vague and difficult to diagnose at an early stage. Genotoxicity and cancers can also occur. Metal toxicity can have acute or chronic manifestations. Heavy metals disrupt cellular events including growth, proliferation, differentiation, damage-repairing processes, and apoptosis. Toxic metals can also promote epigenetic alterations which can influence gene expression. Some toxic metals including Cr, Cd, and As cause genomic instability. Defects in DNA repair following the induction of oxidative stress and DNA damage by these metals is considered as the cause of their carcinogenicity.

Given the background, it is essential to investigate heavy metal contamination prevention and mitigation activity so that the growing concern of heavy metal poisoning in the country can effectively be addressed. Therefore, assessing levels of heavy metals in different water sources is important for proper human health risk assessment.

The present proposal stems from the need to assess the concentrations of different heavy metals in the drinking water used by low/low -middle income groups and to further assess the health hazards associated with the consumption of heavy metal-contaminated water.

REVIEW OF LITERATURE

(a) International Status:

The greatest threat of toxic heavy metals and arsenic is reported in the drinking water and groundwater of several countries, including Mexico, Saudi Arabia, India, Bangladesh, China, Chile, Thailand, and Iran (WHO, 2013). In Sonora, Mexico, approximately 43% of a drinking water sample from storage tanks and wells were observed to have elevated levels of Cd, As, Hg, Cu, and Pb (WHO, 2013). The concentrations of Cd, Pb, and Cu in drinking water in ten cities of Saudi Arabia exceeded the guideline value, which was attributed to the Kuwaiti and the Gulf War oil fires (Chowdhury et al, 2016).

In the last 14 years, data on Arsenic contamination in Bangladesh showed that 42.1% of the drinking samples had As above 50 μg/L (EPA, 2012 & WHO, 2011). The average concentrations of Pb, Cr, Ni, and Zn in drinking water in some metropolitan cities of Iran (Hadiani, 2015; Mosaferi, 2008; Savari 2008) and Thailand (Wongsasuluk, 2014; Li, 2016) exceeded the guidelines value, which was linked to the pipeline corrosion and poor domestic treatment. Several studies have evaluated the level of toxic metals in drinking water and reported that the concentrations of these metals from Germany, USA, Jordan, Malaysia, and Turkey are below permissible limits (EPA, 2012 & WHO, 2013)

(b) National Status:

In different states of India, drinking water has been shown to contain quantities of heavy metals in diverse ratios, according to several studies. The formulation of potential solutions for risk management and control benefits greatly from this information. Data on heavy metal contamination of groundwater in most rural areas of India over the past ten years revealed that average concentrations of As, Mn, Cr, Pb, Ni, and Zn in drinking water were higher than WHO

recommendations. This was related to the pharmaceutical, paint, pesticide, and fertilizer industries, as well as the manufacturing of pharmaceuticals and other products (Bajwa et al, 2017). Jaiswal assessed the levels of heavy metals in monsoon and non-monsoon season in river Yamuna in Uttar Pradesh, India and observed that except for iron (Fe), the mean levels of all metals (i.e Cd, Cr, As, Pb) were within drinking water safe limits in both seasons (Jaiswal et al, 2022). However, no health risks from HMs contamination via drinking water in the region from different sources of Garhwal Himalaya was observed (Prasad et al, 2022). Analysis of arsenic levels in 25 water samples collected from 25 booster pumping stations and 313 water samples collected from tap water supply of 62 areas of Delhi observed that the mean arsenic level detected in water samples of booster pumping station was within WHO/EPA permissible limit while mean arsenic level detected in tap water samples was marginally higher (**Lalwani et al, 2006**). The concentrations of Mn, Cd, and Pb in drinking water in India exceeded the guideline value, which was attributed to the geo-genic contamination. (Bajwa et al, 2017). Study conducted by **Gupta et al**, detected iron (Fe), copper (Cu), and arsenic (As) in groundwater samples of Kanpur, Uttar Pradesh. Of which, one sample showcased the presence of chromium (Cr), and two samples showed lead (Pb) contamination. (Gupta et al, 2022). Study by Mahalakshmi, 2022 revealed the presence and distribution of HMs in water and soil sediments of various places in Vellore District, Tamil Nadu, India. The dominance of various HMs in the soil sediment sample followed the order strontium (Sr) > Manganese (Mn) > Barium (Ba) > Zinc (Zn) > Nickel (Ni) and Sr > Mn > Zn > Boron (B) >, respectively. The results of the study also showed that the presence of HMs in water and soil sediments could be threatened with pollution factors unsafe for irrigation, drinking, and other human activities.

On analysis of 382 groundwater samples from 58 villages of Prakasam district, Andhra Pradesh, for heavy metals and strontium observed high dosages of HMs and Sr which indicated a significant carcinogenic risk for adults and children (Khandare et al, 2020). According to a 2011 study by Dutta, there was more arsenic than permitted (0.01 ppm) according to WHO criteria in the drinking water of 6 tiny tea gardens in Sonitpur district, Assam (Dutta, 2022).

In the groundwater survey of representative sites across all districts of the State of Bihar, Richards et al. found quantities of arsenic and uranium that were higher than (provisional) guideline values in roughly 16% and 7% of samples, respectively**.** In a previous study, Ajmal & Uddin found that the levels of heavy metals in the water at Aligarh Muslim University in India were substantially below the standards set by the World Health Organization for the quality of drinking water (1984). According to the study's findings, drinking water may not pose a substantial risk to consumers'

health owing to heavy metals, but these substances may be dangerous if they accumulate in the body because of long-term, continuous intake.

Table 1: The permissible limits (ppm) of some heavy metal ions in drinking water

Heavy Metal Ions	**WHO**	**US EPA**
Lead, as Pb	0.05	0.015
Cadmium, as Cd	0.005	0.005
Chromium, as Cr	0.05	0.05
Mercury, as Hg	0.001	0.002
Arsenic, as As	0.05	0.01

Table 2: Heavy Metals and their Effect on Human Health

Heavy Metal Ions	Sources	Effects
Lead, as Pb	Lead comes into water due to intense anthropogenic activities (e.g., pigments, electroplating, and battery manufacturing). These industries have also been revealed to discharge effluents containing Pb into the aquatic environment **(Bharadwaj, 2017)**	Liver, kidney damage, physiological damage, affects health of children, learning disability
Cadmium, as Cd	Cadmiun comes into water from Cd-containing fertilizers, combustion emissions, and industrial activities (e.g., mining and metal industry)	Kidney damage, respiratory problems, gastrointestinal disorder, bone marrow, Itai-Itai disease
Chromium, as Cr	Cr levels may end up in rivers due to dissolution from rain and industrial activities (e.g., electroplating, textile, metal finishing, and leather tanning)	Kidney dysfunction, GastroIntestinal disorder, increasing the incidence of cancer including lung cancer, bladder, kidney, thyroid etc
Mercury, as Hg	Mercury may end up in water due to atmospheric contamination. Also, some water bodies also receive mercury from direct discharge of industrial wastes, mining wastes, or naturally occurring mercury minerals.	Damage to the nervous system, bone diseases, poisoning, cancer, Minamata disease, very toxic
Arsenic, as As	Arsenic comes into water from weathering and leaching of rocks, arsenical pesticides, fertilizers, and disposal of industrial and animal wastes **(Kumar, 2020)**	Bronchitis, dermatitis, cancer, physiological changes, mental retardation, very toxic

STUDY OBJECTIVES

Primary Objective

To evaluate the concentrations of heavy metals in drinking water samples taken from different parts of Delhi NCR.

Secondary Objective

1. To compare the levels of heavy metals with national and international standard
2. To identify the potential health risks associated with detected levels.
3. To provide recommendations for mitigating heavy metal contamination.

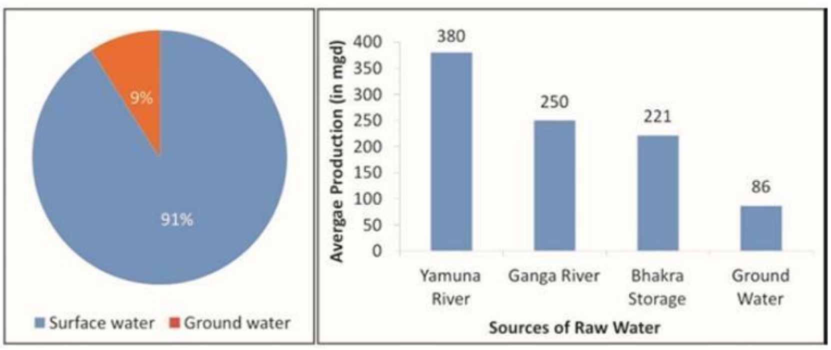
Methodology

Study Design: Cross-sectional study involved sample collection and analysis.

Study Area: Select locations across Delhi NCR representing diverse demographics and potential contamination sources. Dwarka, Sadatpur, Shahdra and Mundka.

The study will be carried out in the National Capital Territory of Delhi which is divided into 11 districts. Delhi relies on multiple external and internal sources to meet its water needs. The Delhi Jal Board obtains raw water to produce potable water from various sources. According to available data, 91 percent of raw water is obtained from surface sources (i.e., rivers and canals) and nine percent from underground sources. (**Figure 1**)

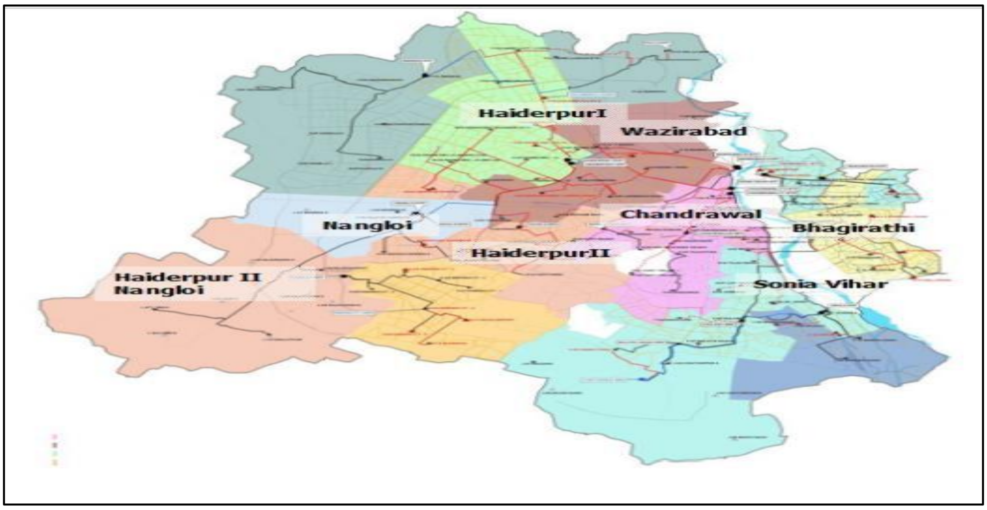
Figure 1: Sources of Raw Water -Delhi



Source: *Planning Department, Economic Survey of Delhi 2019-20, 232.*

Delhi has a total of 9 **Water Treatment Pants** which in turn receive water from various raw water sources. Besides this, Delhi also has **Recycling plants** that process wastewater in the existing plants. In addition to this, it has **Ranney wells & Tube** wells that receive ground water. Given below is a map showing locations of water treatment plants in Delhi.

Map Showing Location of Water Treatment Plants in Delhi



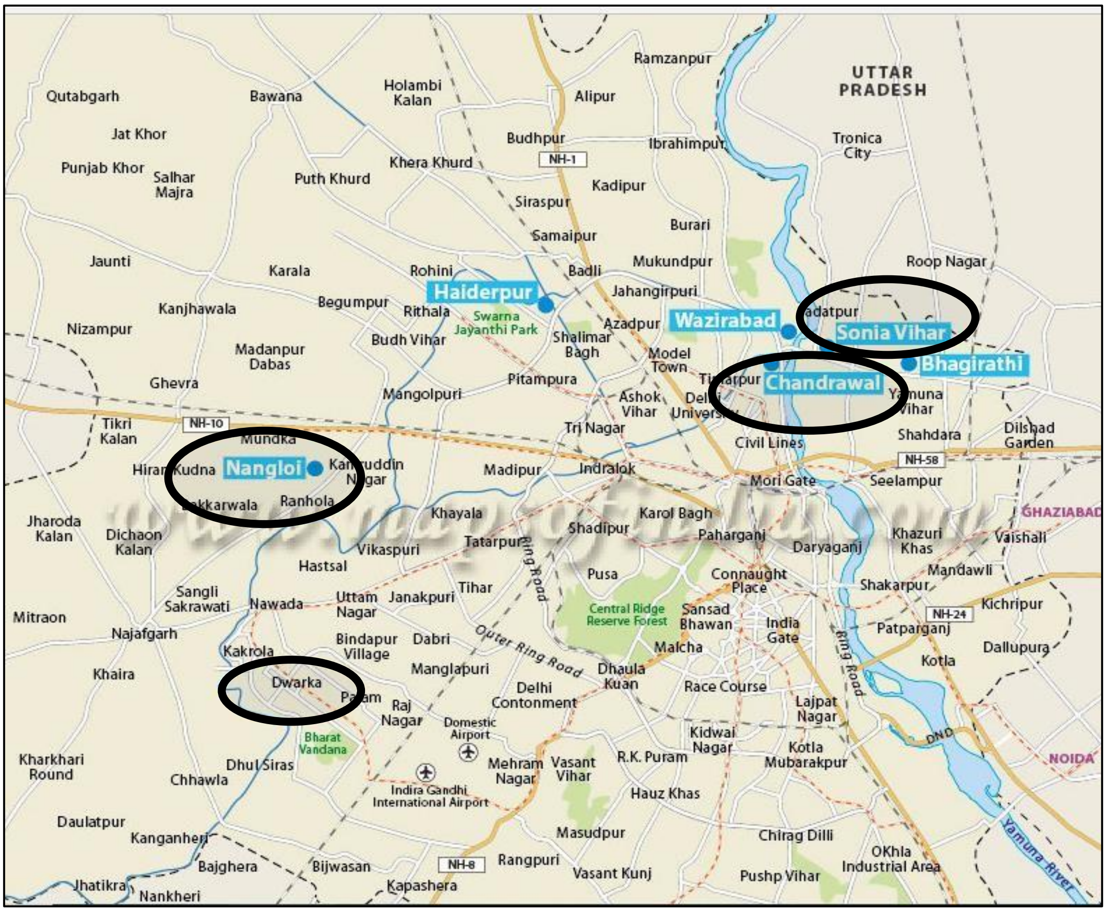
List of Water Treatment Plants and their Source of Raw Water

S. No.	Name of WTP	Installed Capacity of WTP (in MGD)	Average Production (in MGD)	Source of Raw Water
1	Sonia Vihar	140	140	Upper Ganga Canal
2	Bhagirathi	100	100	Upper Ganga Canal
3	Chandrawal I & II	90	95	River Yamuna

4	Wazirabad I, II & III	120	123	River Yamuna
5	Haiderpur I & II	200	210	Bhakra Storage & Yamuna
6	Nangloi	40	40	Bhakra Storage
7	Okhla	20	20	Raw water from Munak Canal
8	Bawana	20	15	
9	Dwarka	50	40	
10	Recycling Plants	45	40	Process wastewater in the existing plants
11	Ranney wells & Tube wells	80	80	Ground Water

As mentioned in the table, Sonia Vihar and Bhagirathi Water Treatment Plants receive their raw water from the **Upper Ganga Canal**; Chandrawal I & II & Wazirabad I, II & III receive raw water from **River Yamuna**; Haiderpur and Nangloi receive water from **Bhakra Storage** and Okhla, Bawana, Dwarka from the **Munak Canal**.

Water treatment plants selected for the study are marked in the map below.



Socio-Demographic Details: Age, gender, socio-economic status, education, religion, marital status, occupation, tobacco and alcohol consumption, physical activity, obesity, dietary practices, current medical problems cancer, cardiovascular disorders, neuronal damage, renal injuries, diabetes cancer, mental illness, etc would be recorded, along with family history of any disorder will be collected.

Study Population: Residents drinking water from various sources (e.g., bore wells, municipal supplies, and bottled water).

Sample Size: 41 Sample size will calculated based on desired statistical power and population distribution. Convenient sampling will be used.

Study Period: March to June 2024

Samling Technique: A convenient sampling technique will be used to cover the sample size.

Study Variables: Independent variable: Heavy metal concentration in water samples (e.g., arsenic, lead, chromium)

Dependent variable: Potential health outcomes (self-reported through surveys)

Data Collection Tools And Techniques: Water Sample Collection Equipment: This will involve using sterile containers, the right preservation technique, and the right labeling to ensure identification.

Surveys: Residents were asked to complete standardized questionnaires with questions on their drinking water source, any possible health problems they may be having, and any other relevant behavioral or demographic data.

Data Analysis: By MS Excel and SPSS

Elemental Concentrations Measurements: To estimate the level of heavy metals in drinking water, 25 samples would be taken from each region. The water used for drinking by the families which could be RO water, tap water, borewell, handpump water etc. will be collected and tested. Water samples will be analyzed for five heavy metals-Pb, Cd, Cr, Hg, As. All the collected water samples will be placed in cleaned plastic containers. The heavy metals will be measured by Optical emission spectroscopy by outsourcing to a clinical laboratory.

Results

Levels of heavy metals with national and international standards

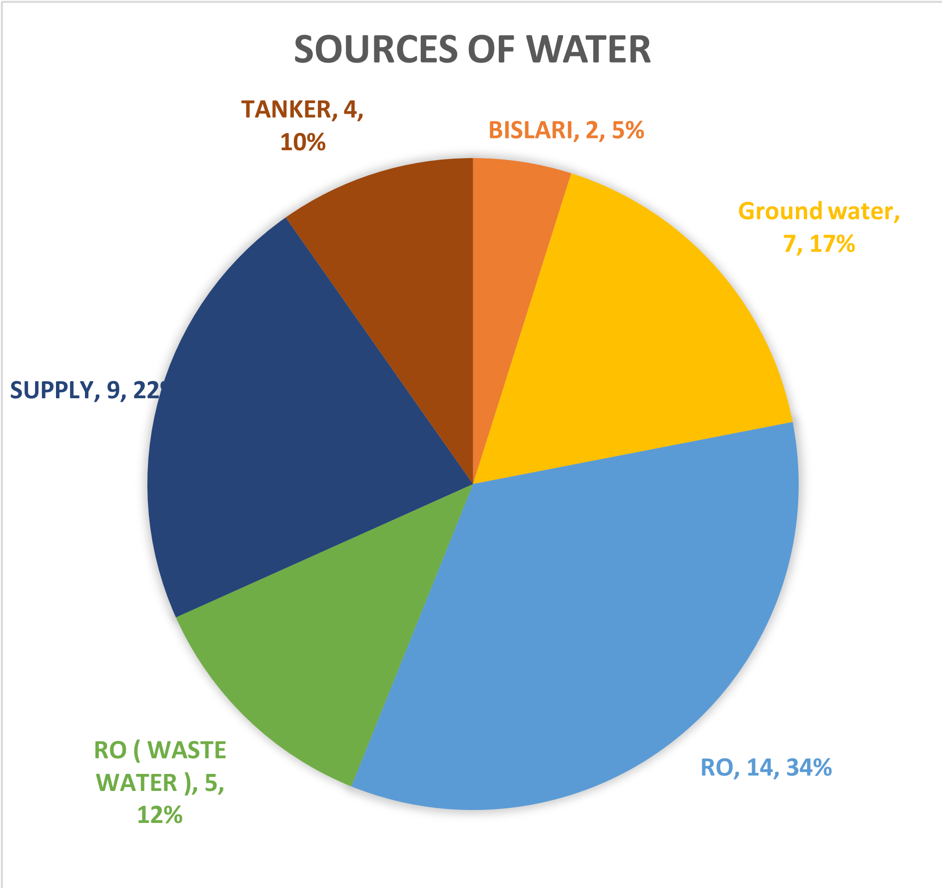
Heavy metals	Desirable	permissible
CaCO3 (Mg/L)-600mg/L	300	600
Chloride (Mg/L)-200-300	250	1000
Cu (Mg/L)-2	0.05	1.5
Total Iron as Fe	0.3	1
Mn (Mg/L)-0.4	0.1	0.3
Sodium as Na		200
S04 (mg/L)-250	200	400
Zinc as Zn (mg/l)-5	5	15
Ca (Mg/L)-100-300	75	200
Mg (Mg/L)-50 mg/l	30	100
K(Mg/L)-12mg/l		
Phosphorous(Mg/L)-1mg/L		1
As (Mg/L)-0.01	0.05	0.01
Cd (Mg/L)-0.003	0.01	
Chromium as Cr6+ (Mg/L)-0.05		0.05
F (Mg/L)-1.5	1	1.5
Lead (Mg/L) -0.01	0.05	
Hg (Mg/L)-0.006	0.001	

The provided table outlines the desirable and permissible limits for various heavy metals and substances in drinking water, based on national and international standards. Key elements include:

- **CaCO3:** 300 mg/L desirable, 600 mg/L permissible; impacts water hardness.
- **Chloride:** 250 mg/L desirable, 1000 mg/L permissible; affects taste and corrosion.
- **Copper:** 0.05 mg/L desirable, 1.5 mg/L permissible; higher levels cause gastrointestinal issues.
- **Iron:** 0.3 mg/L desirable, 1 mg/L permissible; higher levels cause staining and taste issues.
- **Manganese:** 0.1 mg/L desirable, 0.3 mg/L permissible; higher levels affect neurological health.
- **Sulfate:** 200 mg/L desirable, 400 mg/L permissible; high levels cause laxative effects.
- **Zinc:** 5 mg/L desirable, 15 mg/L permissible; higher levels cause taste and gastrointestinal issues.
- **Calcium and Magnesium:** Manage hardness; higher levels cause scaling.

- **Arsenic, Cadmium, Chromium, Lead, Mercury:** Highly toxic, strict limits to minimize health risks.

Sources of Drinking Water



SOURCE OF WATER	Frequency	Percent	Valid Percent	Cumulative Percent
		14.6	14.6	14.6
BISLARI	2	4.2	4.2	18.8
		2.1	2.1	20.8
Ground water	7	12.5	12.5	33.3
RO	14	29.2	29.2	62.5
RO (WASTE WATER)	5	10.4	10.4	72.9
SUPPLY	9	18.8	18.8	91.7
TANKER	4	8.3	8.3	100.0
		100.0	100.0	

The data presents the distribution of drinking water sources among a surveyed population. "RO" (Reverse Osmosis) water is the most common source, used by 29.2% of respondents. Groundwater and municipal supply water are also significant, accounting for 12.5% and 18.8% respectively. Bisleri, a brand of bottled water, is used by 4.2%, while tankers provide water for 8.3%. A notable 10.4% use waste water from RO systems. The remaining unspecified sources account for 14.6%. The cumulative percentages indicate the increasing total share as each source is added, reaching 100% when all are combined. The data highlights a diverse range of water sources in use, with a preference for treated water.

The concentrations of heavy metals in drinking water samples

	CaCO3 (Mg/L)-600mg/L	Chloride (Mg/L)-200-300	Cu (Mg/L)-2	Total Iron as Fe	Mn (Mg/L)-0.4	Sodium as Na	S04 (mg/L)-250	Zinc as Zn (mg/l)-5	Ca (Mg/L)-100-300	Mg (Mg/L)-50 mg/l	K(Mg/L)-12mg/l	Phosphorous(Mg/L)-1mg/L	As (Mg/L)-0.01	Cd (Mg/L)-0.003	Chromium as Cr6+ (Mg/L)-0.05	F (Mg/L)-1.5	Lead (Mg/L) -0.01	Hg (Mg/L)-0.006
Desirable	300	250	0.05	0.3	0.1		200	5	75	30			0.05	0.01	0.05	1	0.05	0.001
permissible	600	1000	1.5	1	0.3		400	15	200	100						1.5		
Mean	79.707	64.376	.004232	.0993	.0286449	3.6132	25.9151	.4332	9.429	15.944	1.451	1.0917	.000093	0.0000	.008783	.2551	.001785	0.000000
Median	28.000	24.400	.001300	.0300	.0015000	.9000	10.2000	.1400	2.800	5.400	.500	.2000	0.000000	0.0000	0.000000	.0900	0.000000	0.000000
Std. Deviation	119.3363	96.3738	.0089785	.12545	.10311259	6.00195	37.67749	.58377	14.7159	22.4376	2.3364	1.82363	.0003357	0.00000	.0437964	.34911	.0060520	0.0000000
Range	510.0	410.8	.0400	.47	.53900	24.16	161.68	2.17	68.5	96.9	8.8	6.80	.0014	0.00	.2800	1.54	.0280	0.0000
Minimum	6.0	3.4	.0010	.01	.00100	.04	.12	.10	.9	.2	.1	0.00	0.0000	0.00	0.0000	.02	0.0000	0.0000
Maximum	516.0	414.2	.0410	.48	.54000	24.20	161.80	2.27	69.4	97.1	8.9	6.80	.0014	0.00	.2800	1.56	.0280	0.0000

The data provided pertains to various chemical parameters in drinking water and includes values for CaCO3, chloride, copper (Cu), total iron as Fe, manganese (Mn), sodium as Na, sulfate (SO4), zinc (Zn), calcium (Ca), magnesium (Mg), potassium (K), phosphorus, arsenic (As), cadmium (Cd), chromium as Cr6+, fluoride (F), lead (Pb), and mercury (Hg). For each parameter, the dataset includes maximum permissible limits, desirable limits, and statistical measures such as mean, median, standard deviation, range, minimum, and maximum values.

Desirable and Permissible Limits: These indicate the concentration ranges deemed safe for human consumption. For example, the desirable limit for chloride is 250 mg/L, while the permissible limit is 1000 mg/L.

Mean and Median Values: The mean value represents the average concentration, while the median value is the midpoint of the dataset, indicating the central tendency. For instance, the mean chloride concentration is 64.376 mg/L, while the median is 24.4 mg/L, suggesting a skewed distribution.

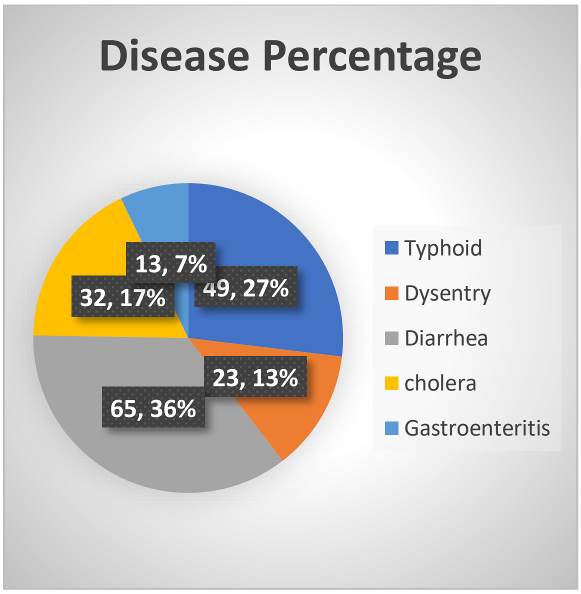
Standard Deviation and Range: The standard deviation measures the variation in data, while the range indicates the spread between the minimum and maximum values. A high standard deviation, like 119.3363 mg/L for $CaCO_3$, signifies wide variability in concentration levels.

Minimum and Maximum Values: These indicate the observed lowest and highest concentrations. For instance, the minimum calcium concentration is 0.9 mg/L, and the maximum is 69.4 mg/L.

Comparison with Limits: The data shows that mean concentrations of all parameters are well within the permissible limits, indicating overall safe levels. However, the maximum values for some parameters like $CaCO_3$ and chloride occasionally approach or exceed desirable limits, highlighting potential areas of concern.

This dataset helps assess the quality of drinking water by comparing observed concentrations with established safety thresholds, identifying trends, and pinpointing areas that may require further investigation or intervention.

The potential health risks associated with detected levels



Disease	Percentage
Typhoid	49
Dysentry	23
Diarrhea	65
cholera	32
Gastroenteritis	13

The information provided shows how common waterborne illnesses are in a particular community. The most prevalent, impacting 65% of people, is diarrhoea, which suggests that problems with water sanitation and hygiene are pervasive. With a 49% frequency, typhoid fever indicates a high level of Salmonella typhi infection, most likely from consuming tainted food or water. With 32% of cases, cholera indicates serious Vibrio cholerae contamination, usually as a result of subpar sewage and water treatment systems.

At 23%, dysentery is frequently caused by diseases like as Entamoeba histolytica or Shigella, which are typically transmitted by polluted water and inadequate hygiene standards. With a frequency of 13%, gastroenteritis is an inflammation of the intestines and stomach that is often caused by bacterial, viral, or parasite diseases that are also connected to polluted water sour

These high percentages point to serious problems with water safety and cleanliness in the public health domain. To lower the prevalence of these illnesses, quick actions are required, such as enhancing water treatment facilities, encouraging safe water habits, and making sure sewage is disposed of properly. Campaigns for public health education that emphasise good hygiene habits may also be able to slow the development of these illnesses.

Discussion

Calcium: All samples have low concentration and below desirable limits, low calcium levels in drinking water may not directly impact health but can contribute to insufficient dietary intake, potentially increasing the risk of osteoporosis and bone-related disorders over time. Adequate calcium intake is essential for maintaining bone health, particularly in populations with already low dietary calcium sources.

Phosphorous: 18 percent of our samples are above high phosphorus levels in water can promote harmful algal blooms, which produce toxins harmful to human health and ecosystems. Exposure to these toxins through contaminated water can cause skin irritation, gastrointestinal issues, and liver damage. It can also lead to oxygen depletion, threatening aquatic life and ecosystems.

Magnesium: 83 percent of samples have low magnesium levels in drinking water can lead to muscle cramps, fatigue, and irregular heart rhythms. Chronic deficiency may increase the risk of cardiovascular diseases like hypertension and heart disease. Magnesium is crucial for nerve function, muscle health, and overall cardiovascular well-being, highlighting the importance of adequate intake.

Fluoride: 93% of samples have low fluoride levels in drinking water can increase the risk of dental cavities, as fluoride helps strengthen tooth enamel and prevent decay. Insufficient fluoride intake can lead to higher dental treatment costs and oral health issues, particularly in children and communities without access to other fluoride sources. 1 sample have High fluoride levels in drinking water can cause dental fluorosis, characterized by discoloration and pitting of tooth enamel. Prolonged exposure can lead to skeletal fluorosis, resulting in joint pain and bone deformities. Excessive fluoride intake is particularly harmful to children, affecting tooth and bone development.

Zinc: All samples have low zinc levels in drinking water can lead to weakened immune function, slower wound healing, and impaired taste and smell. Zinc deficiency can also affect growth and development in children, increase susceptibility to infections, and cause skin issues like dermatitis. Adequate zinc is essential for overall health and well-being.

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Conclusion

This study highlights the urgent need to address heavy metal contamination in Delhi NCR's drinking water. The detected levels of calcium, magnesium, fluoride, and zinc are below safe limits, And the amount of phosphorus and fluoride has exceeded safe limits posing severe health risks to residents. The high prevalence of waterborne diseases further emphasizes the critical nature of this issue.

Immediate actions are required, including:

Regulatory Measures: Implement and enforce stringent regulations on industrial waste disposal.

Regular Monitoring: Conduct regular and comprehensive monitoring of water quality.

Public Awareness: Educate the public on safe drinking water practices.

Purification Technologies: Develop and deploy effective water purification technologies.

These steps are essential to ensure safe drinking water and protect public health in Delhi NCR.

REFERENCE

1. Ajmal M, Uddin R. Quality of drinking water in the Aligarh Muslim University Campus, Aligarh, U.P. (India) with respect to heavy metals. Environ Monit Assess. 1986 Mar;6(2):195-205. doi: 10.1007/BF00395630. PMID: 24254648.
2. Bajwa BS, et al. Uranium and other heavy toxic elements distribution in the drinking water samples of SW-Punjab, India. Journal of Radiation Research and Applied Sciences. 2017;10(1):13–9.
3. Bhardwaj R, Gupta A, Garg JK. Evaluation of heavy metal contamination using environmetrics and indexing approach for River Yamuna, Delhi stretch, India. Water Sci. 2017; 31: 52–66. https://doi.org/10.1016/j.wsj.2017.02.002
4. Edition F. Guidelines for drinking-water quality. WHO chronicle. 2011; 38(4):104–8.
5. EPA. Edition of the Drinking Water Standards and Health Advisories. 2012: EPA 822-S-12-001. Washington, DC: Office of Water U.S. Environmental Protection Agency; 2012.
6. Gleick, P. H. Global freshwater resources: soft-path solutions for the 21st century. Science 2003, 302, 1524– 1528, DOI: 10.1126/science.1089967
7. Gupta V, Kumar D, Dwivedi A, Vishwakarma U, Malik DS, Paroha S, Mohan N, Gupta N. Heavy metal contamination in river water, sediment, groundwater and human blood, from Kanpur, Uttar Pradesh, India. Environ Geochem Health. 2022
8. Hadiani MR, et al. Trace elements and heavy metals in mineral and bottled drinking waters on the Iranian market. Food Additives & Contaminants: Part B. 2015;8(1):18–24.
9. Khandare AL, Validandi V, Rajendran A, Singh TG, Thingnganing L, Kurella S, Nagaraju R, Dheeravath S, Vaddi N, Kommu S, Maddela Y. Health risk assessment of heavy metals and strontium in groundwater used for drinking and cooking in 58 villages of Prakasam district, Andhra Pradesh, India. Environ Geochem Health. 2020 Nov;42(11):3675-3701. doi: 10.1007/s10653-020-00596-1. Epub 2020 Jun 2. PMID: 32488799.
10. Kumar M, Sharif M, Ahmed S. Impact of urbanization on the river Yamuna basin. Int. J. River Basin Manage. 2020;18: 461–475. https://doi.org/10.1080/15715124.2019.1613412
11. Lalwani S, Dogra TD, Bhardwaj DN, Sharma RK, Murty OP. Study on arsenic level in public water supply of Delhi using hydride generator accessory coupled with atomic absorption spectrophotometer. Indian J Clin Biochem. 2006
12. Li Y, et al. Concentrations and health risk assessment of metal (loid) s in indoor dust from two typical cities of China. Environmental Science and Pollution Research. 2016;23(9):9082–92.
13. M. Bamuwuwamye, P. Ogwok, V. Tumuhairwe, R. Eragu, H. Nakisozi, P.E. Ogwang. Human health risk assessment of heavy metals in Kampala (Uganda) drinking water J. Food Res., 6 (4) (2017), pp. 616.
14. Mohan SV, Nithila P, Reddy SJ. Estimation of heavy metals in drinking water and development of heavy metal pollution index. Journal of Environmental Science and Health Part A 31 (1996): 283-289
15. Mosaferi M, et al. Prevalence of skin lesions and exposure to arsenic in drinking water in Iran. Science of the total environment. 2008;390(1):69–76.
16. P.H. Li, S.F. Kong, C.M. Geng, B. Han, B. Lu, R.F. Sun, R.J. Zhao, Z.P. Bai Assessing hazardous risks of vehicle inspection workers' exposure to particulate heavy metals in their workplace Aerosol. Air
Qual. Res., 13 (1) (2013), pp. 255-265 doi.org/10.4209/aaqr.2012.04.0087

17. Prasad M, Aswal RS, Joshi A, Kumar GA, Ramola RC. A systematic study on occurrence, risk estimation and health implications of heavy metals in potable water from different sources of Garhwal Himalaya, India. Sci Rep. 2022 Nov 28;12(1):20419
18. Rehman K, Fatima F, Waheed I, Akash MSH. Prevalence of exposure of heavy metals and their impact on health consequences. J Cell Biochem. 2018 Jan;119(1):157-184. doi: 10.1002/jcb.26234. Epub 2017 Aug 2. PMID: 28643849.
19. Richards LA, Kumar A, Shankar P, Gaurav A, Ghosh A, Polya DA. Distribution and Geochemical Controls of Arsenic and Uranium in Groundwater-Derived Drinking Water in Bihar, India. Int J Environ Res Public Health. 2020
20. Savari J, et al. Heavy metals leakage and corrosion potential in Ahvaz drinking water distribution network. Water Wastewater J. 2008;18(64):16–24.
21. Tchounwou PB, Yedjou CG, Patlolla AK, Sutton DJ. Heavy metal toxicity and the environment. Mol
Clin Environ Toxicol. 2012; 101: 133–164. pmid:22945569
22. Tchounwou, P. B.; Yedjou, C. G.; Patlolla, A. K.; Sutton, D. J. Heavy Metals Toxicity and the Environment. EXS 2012, 101, 133– 164, DOI: 10.1007/978-3-7643-8340-4_6
23. USEPA (US Environmental Protection Agency). Definitions and general principles for exposure assessment. Guidelines for exposure assessment. Washington, D.C. Office of Pesticide Programs, USA. 1992
24. USEPA (US Environmental Protection Agency). Risk Assessment Guidance for Superfund, Vol 1.Human Health Evaluation Manual. Part A (interim final), EPA/540/1-89/002. Office of Emergency and Remedial Response, Washington, DC, USA. 1989.
25. Wongsasuluk P, et al. Heavy metal contamination and human health risk assessment in drinking water from shallow groundwater wells in an agricultural area in Ubon Ratchathani province, Thailand. Environmental geochemistry and health. 2014;36(1):169–82.
26. World Health Organization. Drinking-Water Fact-Sheet. http://www.who.int/mediacentre/factsheets/fs391/en/.
27. WWAP (United Nations World Water Assessment Programme). Water for a Sustainable World; The United Nations World Water Development Report: UNESCO:Paris, 2015; pp 1–67

ANNEXURE:

INFORMED CONSENT FORM

International Institute of Health Management (IIHMR) Delhi

Title of the Study: Assessment of Heavy Metals in Drinking Water in Delhi, India

Researcher: Rahul Prakash

You are invited to participate in a research study conducted by the International Institute of Health Management (IIHMR) Delhi. This study aims to evaluate the level of heavy metals in drinking water in different parts of Delhi, India's National Capital Region.

The interaction will take approximately 20-25 minutes. I'll question you about your personal information, your lifestyle choices, including food and exercise, as well as some concerns regarding stress and your health at this period. Your provided information is private and will not be shared with other parties. It will only be applied to future studies.

It is voluntary for you to participate in the survey. You can end the interview at any moment, but if there are any questions you don't want to answer, just let me know and I'll go on to the next one. Without your consent, we won't record this interview or take any pictures.

You can ask me anything right now if you have any questions regarding this survey. You can get in touch with me if you have any more questions regarding this survey afterwards.

Are you willing to take part in this survey? By signing this permission form, you are expressing your understanding of the requirements and your willingness to take part in the survey.

I've read the information that was provided above. I've had the chance to ask questions and have gotten good responses. I am aware that participation is completely optional and that I can end it whenever I choose, for any reason, and without repercussions. I consent to taking part in this research.

Participant's Name: ___________________________________

Participant's Signature: ______________________________

Date: ____

Researcher's Name: ________________________________

Researcher's Signature: _____________________________

Date: ____

If the Respondent Agrees, then begin the Interview.

If the Respondent Refuses, Thank the Respondent and end the Interview.

Epidemiological Profile Questioner

S. No.	Mohalla/Location महल्ला ु /स्थान	Unique ID

A. HOUSEHOLD COMPOSITION OF RESPONDENT

बी. प्रतिवादी की पारिवारिक संिचना

Type of Family (joint/ nuclear): परिवाि का प्रकाि (संयक्तु /एकल):

Sl. No.	S e x ललग	Age (Year/ Month/ Days) आयु (वर्ष/ महीना/ दिन)	Relation ship with ego संबंध अहंकाि के साथ	Present Marital Status उप स्थथत वैवा दहक स्थथ तत	Educational Status 1. Primary 2. Secondary 3. And above शैक्षणिक स्थथतत 1. प्राथलमक 2. गौि 3. अिौ ऊपि	Occupational Status व्यावसा तयक स्थथतत	Monthly income from all sources महीने के आय सभी से सत्रोंू का कहना है	Total monthly income of household कुल महीने के की आय परिवाि	Monthly household expense on Kitchen महीने के परिवाि व्यय िसोई पि	Any kind of Illness? Name and duration ककसी तिह का बीमा िी? नाम एवं अवधध	Any treatment Given? If yes, what? कोई इलाज दिया गया? अगि हाँ क्या?
1.											
2.											
3.											
4.											
5.											
6.											
7.											
8.											
9.											
10.											

B. ALCOHOL/ TOBACCO/ DRUG CONSUMPTION BY EGO/FAMILY MEMBER: सी. अहंकाि/परिवाि के सदस्य द्वािा शिाब/िंबाकू /नशीले पदार्थों का सेवन:

	You/Fa mi ly member/ Both आप/परिवाि के सिथय/ िोनों	Yes / No ? हां / नहीं ?	Regular/ Occasio n al तनयलमत/ प्रासंधगक	Age at which you started to take स्जस उम्र में आप ने लेना शरू ु कक या	Frequen cy per day प्रतत दिन आवत्ृि	Quantit y per day (average in ml) प्रतत दिन मात्रा (एमएल में औसत)	Do you take during pregnancy? क्या आप गभाषवथथा के िौिान लेते हैं?	Frequency per day during Pregnancy के िौिान प्रतत दिन आवत्ृि गभाषवथथा
Alcohol/locall y fermented beer* अल्कोहल/तथा नीय रूप से ककस्ववत बबयि*								
Tobacco/Pan** तम्बाकू /पान**								
Other drugs (specify) *** अन्य और्धयााँ (तनदिषष्ट किं) ***								

* Mahua; Whisky; Rum; any other

** Chewing; Smoking; direct tobacco; beedi; cigarette; zarda; any other *** Charas; Ganja; Bhang; Opium; L.S.D; Brown Sugar; any other

*महुआ; स्व्हथकी; िम; कोई अिौ

** चबाना; धम्रपानू ; प्रत्यक्ष तम्बाकू ; बीडी; लसगिेट; ज़िाष; कोई अिौ

*** चिस; गांजा; भांग; अफीम; एल.एस.डी.; ब्राउन शगुि ; कोई अिौ

C. Nutritional Status डी. पोषण संबंधी स्स्थति

Dietary Habit (Veg/Non-Veg) आहाि संबंधी अिात (शाकाहािी/गैि-शाकाहािी)	
Source of Water (Tap / tank / tube-well / hand or motor pump / pond / well/river) जल का स्रोत (नल/टैंक/ट्यबवलेू /हाथ या मोटि पंप/तालाब/कु आं/नी)	
Domestic Servants: M- F- घिलू नौकि: एम- एफ-	
Kind of Milk (Domestic source / milkman / mother dairy/ Cow/ buffalo / goat): िधू का प्रकाि (घिलू स्रोत/िधवालाू /मिि डेयिी/गाय/भसैं/बकिी):	
Amount Consumed (L/day): उपभोग की गई िालश (एल/दिन):	
No of Full Meals: पिषू भोजन की संख्या:	
Frequency of Non-Vegetarian Food: मांसाहािी भोजन की आवत्तृि :	
Frequency of Vegetarian Food: शाकाहािी भोजन की आवत्तृि :	
Frequency of Milk Products: िग्ध ु उत्पािों की आवत्तृि :	
Frequency of Pulses: िालों की आवत्तृि :	
Frequency of Fruits: फलों की आवत्तृि :	
Any other specific diet कोई अन्य त्तवलशष्ट आहाि	
History of Any Nutritional Deficiency: ककसी भी पोर्ि संबंधी कमी का इततहास:	

D. House Type

ई. मकान का प्रकाि

House Type (Kuccha / Jhopri / Pucca): मकान का प्रकाि (कच्चा/झोपडी/पक्का):	
Property Owned (Y/N): Residential/ Agricultural/ Commercial/ Others थवालमत्व वाली संपत्ति (Y/N): आवासीय/कृत्तर्/वाणिस्ययक/अन्य	
Locality (Rural / Semi urban / urban / urban slum / urban planned): इलाका (ग्रामीि/अधशष र्हीं/शर्हीं/शर्हीं थलम/शर्हीं तनयोस्जत):	
Household Assets: (A.C. / refrigerator/ TV / VCR / washing machine/ scooter / car) घिेलू संपत्ति: (ए.सी./िेकिजिेटि/टीवी/वीसीआि/वॉलशगं मशीन/थकू टि/काि)	
Domestic Animals (Cows / buffalos / pigs / horses / goats): घिेलू पशु (गाय/भसैं/सअूि /घोडे/बकिी):	
Kitchen Garden (Y/N) ककचन गाडनष (Y/N)	

E. Any Illness एफ. कोई बीमािी

	Type प्रकाि	Age आयु	Duration अवधध
Nutritional Deficiency पोर्ि की कमी			
Physical Disability शािीरिक अपंगता			
Emotional Impairment भावनात्मक क्षतत			
Major Therapeutic Irradiation Exposure प्रमखु धचककत्सीय त्तवककिि एक्सपोजि			
Long Illness लंबी बीमािी			

F. Have you ever been diagnosed by a doctor for any of the following conditions? जी. क्या आपको कभी ककसी डॉक्टि द्वाि‍ा तनम्नललखखि‍ में से ककसी भी स्स्थति का तनदान ककया गया है?

	Type प्रकाि	Age आयु
Heart failure/disease हृिय त्तवफलता/बीमाि‍ी		
Irritable Bowel Disease धचडधचडा आत्रं ि‍ोग		
Chronic Bronchitis क्रोतनक ब्रोंकाइदटस		
Hernia हितनया		
Emphysema वातथफीतत		
Endometriosis अन्तगभष ाषशय-अथथानता		
Arthritis वात ि‍ोग		
Inflammatory bowel disease सजा़ आंत्र ि‍ोग		
Depression		
अवसाि		
Cancer कैं सि		

G. Have you or your family member suffered from any of the listed illness in last 1 year?

क्या आप पपछले 1 वर्ष में किसी सचीबद्धू बीमारी से पीड़ित हैं?

	When & how many times कब औि ककतनी बाि	Age आयु
Typhoid आंत्र यवि		
Diarrhoea िथत		
Amoebic Dysentery अमीबी पेधचश		
Hair fall बाल झडना		
Skin Allergy त्वचा ि‍ोग		
Migraine माइग्रेन		
Eye pain आँख का िि‍ष		

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