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Assessment of Water Quality and its Risk to Human Health Posed by Drinking Water from Open Sources in Jammu and Kashmir

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Abstract: Globally, the quality of the water has been connected to health outcomes. This study assessed the community practices surrounding water collection and storage, the physicochemical and bacteriological quality of drinking water supplied by the public health division from the point of use to the source in Anatnag, and the risks to human health associated with water consumption. A water quality assessment was performed on one hundred samples.
To find out how the community moves water from its source to its point of use and stores it, questionnaires were employed. The majority of the homes (73%) do not purify their water before consumption, and many of them reported frequent interruptions in the water supply. Although total coliform and E. coli were not found in the water samples taken at the reservoir's source, It was discovered that there was significant E. Col and total coliform contamination in the samples taken from the street taps and the domestic storage containers at the point of use. During the rainy season, higher levels of E. Coli and total coliform were found than during the dry season. The amounts of trace metals in the drinking water samples fell below the World Health Organization's and Indian Standards' acceptable limit. Drinking water through ingestion and cutaneous channels has non-carcinogenic effects that are assessed using hazard quotient toxicity potential and cumulative hazard index. These effects are less than unity, which suggests that there may not be a major non-carcinogenic health risk associated with water intake. sporadic disruptions to the water supply as well as specific methods of water storage and transit by residents of the community raise the possibility of contaminated water. We suggest that the province of Kashmir receive a more steady supply of treated water and that its citizens be instructed in hygienic methods for carrying and storing drinking water from the point of origin to the place of use.
Keywords: drinking water, physical, biological, households, human health

I. INTRODUCTION

One of the most important resources for business, agriculture, and human nourishment is water. This outstanding resource serves as the foundation and backbone of social and economic advancement1. Water that is both readily available and of high quality is a basic human right, and the United Nations General Assembly (UNGA) has identified access to clean water and sanitation for everyone as one of the targets to be met by the year 2030 for sustainable development.

Water's quality is defined by its physical, chemical, biological, and aesthetic characteristics, which also affect its suitability for various applications such as safeguarding human health and the aquatic ecosystem. The majority of these characteristics are determined by substances that are suspended or dissolved in water, and human activity and natural processes can both have an impact on water quality. Water security is defined as the ability of a population to protect sustainable access to sufficient amounts and acceptable quality of water for maintaining human well-being and socioeconomic growth, as well as to ensure protection against pollution and water-related disasters and to conserve ecosystems in an atmosphere of peace and political balance.

Even though water is available to most people worldwide, in many locations it is neither safe to drink for humans nor available in adequate amounts to meet basic health needs. According to estimates from the World Health Organization (WHO), 1.1 billion people drink contaminated water worldwide, and 88% of diarrheal illnesses are caused by contaminated water, inadequate sanitation, and unkempt habits. Furthermore, the water supply industry is confronted with significant obstacles as a result of urbanization, global warming, and climate change. Sustainable development is severely impacted by inadequate water supply and quality, particularly in developing nations.

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The Central governments and other pertinent bodies have developed national drinking water standards, in India which should be used as a benchmark for evaluating the quality of the water supplied by the public health division. According to these standards, certain characteristics are deemed to be primary in importance to the quality of drinking water, while others are deemed to be secondary. Generally, the standards for drinking water quality state that faecal indicator bacteria (FIB), especially Escherichia coli (E. coli) or thermo-tolerant coliform (TTC), should not be identified in any 100 mL of drinking water sample.

Despite the availability of these standards and guidelines, numerous WHO and United Nations International Children Emergency Fund (UNICEF) reports have documented faecal contamination of drinking water sources, including enhanced sources of drinking water like the pipe water, especially in low-income countries. Water-related diseases remain the principal cause of a high mortality rate for children under the age of five years worldwide. These issues are particularly prevalent in developing nations' rural areas. Furthermore, people in both industrialized and developing nations have been linked to chronic health issues as a result of new pollutants and disinfection by products. Because of the unreliability of water delivery infrastructures, efforts by both governmental and non-governmental organizations to guarantee water security and safety have been unsuccessful in many places in recent years.

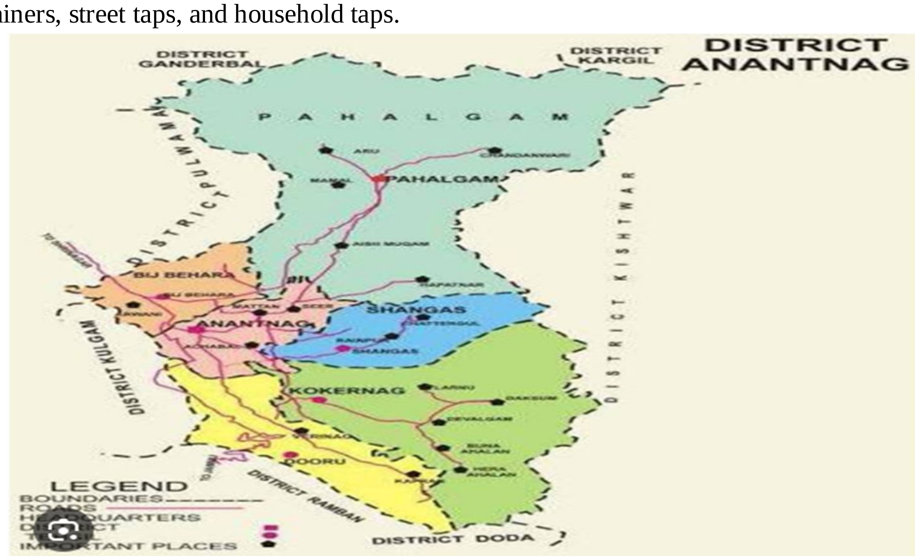
Water quality can be harmed during collection, transportation, and home storage, particularly when it comes to the microbial content. Open field defecation, animal waste, commercial, industrial, and agricultural activities, residential waste, and flooding are all potential sources of contaminated drinking water. Especially any source of water is susceptible to this kind of pollution. Thus, access to a safe source alone does not ensure the quality of water that is consumed, and a good water supply alone does not automatically translate to full health advantages in the absence of improved water storage and sanitation. It has been noted that drinking water in impoverished nations often gets re-contaminated after being collected and stored in households.

Previous studies in developing countries have identified a progressive contamination of drinking water samples with E. coli and total coliforms from source to the point of use in the households, especially as a result of using dirty containers for collection and storage processes. Also, the type of water treatment method employed at household levels, the type of container used to store drinking water, the number of days of water storage, inadequate knowledge and a lack of personal and domestic hygiene have all been linked with levels of water contamination in households. This study examined the methods used by the community to handle drinking water in a rural area of Anantnag district, South Kashmir, from the reservoir to the household point of use. It also assessed the water quality at the household storage containers, yard connections, street taps, and reservoir as well as the main distribution systems. The assessment of water quality involved evaluating the levels of microbiological contamination and trace metals. Additionally, potential health hazards resulting from human exposure to these hazardous microorganisms and trace metals in drinking water were identified.

II. METHODOLOGY

A. Study Area

The research was carried out in the South Kashmiri municipality of Anantnag. The district experiences summertime precipitation most of the time, from March to September, and is typically hot and muggy. 10.70 lac people live in the Anantnag district, which makes up almost 9% of the state's total population. Water samples were gathered for analysis from various open water sources, domestic storage containers, street taps, and household taps.



This study used a quantitative design that included water analysis and field survey.

The purpose of the study was to identify the chosen houses and the street taps that they shared as a supply of drinking water. To facilitate sampling, the community was split into quadrants. Randomly chosen homes from each quadrant were given questionnaires, and water samples from the homes were also taken for examination.

A. Data Collection

A standardized questionnaire that was given by an interviewer was used to gather data from the chosen houses. In order to accurately represent the total population, questionnaires were only given to those between the ages of 18 and 60. In order to address the questionnaires that might be missing important information and, as a result, be ineligible for analysis, a total of 100 questionnaires were issued. Adults between the ages of 18 and 60 were chosen at random to fill out the questionnaire, which asks about the respondents' socioeconomic and demographic characteristics, water use habits, sanitation, and hygiene habits, as well as their opinions about the quality and health of the water. The questionnaire was handed to the respondents, and the researcher was there to answer any questions that might have come up.

B. Water Sampling

At the reservoir, two sampling locations were found, from which a water sample was taken in both the wet and dry seasons. 50 sampling locations were designated for the household storage containers, while sample sites from the street and household taps were also identified. However, because the occupants weren't available during the researcher's visit, only 40 dwelling locations could be used for sample collection.

Water samples were so taken at sixty locations in all. Samples were taken between the hours of 8:00 and 14:30 from each of the sites throughout the wet (20th–30th December, 2023) and dry (15th–25th June, 2023) seasons. During the sampling period, 125 samples were taken in total: from the reservoir, 20 from street taps, 14 from dwelling taps, and 83 from storage systems in homes. 500 mL sterile plastic bottles were used to gather water samples. Following collection, the containers were shipped in a cooler box with ice inside to the laboratory. The concentration of trace metals, microbiological parameters, and physico-chemical parameters were measured for each sample.

C. Analysis of Physicochemical Characteristics

Following Indian Public Health guidelines, procedures, and methods, on-site measurements of temperature, pH, electrical conductivity (EC), and total dissolved solids (TDS) were taken as soon as the samples were taken. The multi-meter used was a model HI "HANNA" instrument. Prior to taking the measurements, the instrument was calibrated in compliance with the manufacturer's instructions. To get a trustworthy reading, the probe was dipped into the water and kept for a few minutes before the value of each sample was determined. To prevent cross-contamination between samples, deionized water was used to rinse the probe after each measurement.

D. Microbiological Assessment of Water Quality.

As advised by APHA, microbiological parameter analysis was carried out within six hours of collection. The United States Environmental Protection Agency (USEPA)-approved IDEXX approach was used to quantify viable total coliform and E. coli in each sample. After adding the collier media to the 100 mL sample, it was well mixed and dissolved. Using the Quanti-Tray sealer26, the solution was sealed after being poured into an IDEXX Quanti-Tray/2000. The samples were incubated for twenty-four hours at 35 °C.

The most likely number (MPN) table supplied by the manufacturer was used to count fluorescent wells in trays that tested positive for E. coli concentration. The trays were scanned using a fluorescent UV lamp.

E. Evaluation of Health Risks

For ingestion and cutaneous routes, risk assessments have been estimated. Equations are used to determine the cutaneous and exposure pathways to water for ingesting. (1) and (2) below

$$\mathrm{Exp}_{\mathrm{ing}} = \frac{IR \times C_{water} \times EF \times ED}{AT \times BW} \qquad (1)$$

$$\text{Exp}_{\text{derm}} = \frac{C_{water} \times SA \times ET \times EF \times ED \times CF \times K_p}{AT \times BW} \quad (2)$$

where Exping: exposure dose through ingestion of water (mg/kg/day);
BW: average body weight (70 kg for adults; 15 kg for children);
Expderm: exposure dose through dermal absorption (mg/kg/day);
Cwater: average concentration of the estimated metals in water (μg/L);
IR: ingestion rate in this study (2.0 L/day for adults; 1.0 L/day for children);
ED: exposure duration (70 years for adults; and 6 years for children);
AT: averaging time (25,550 days for an adult; 2190 days for a child);
EF: exposure frequency (365 days/year)
SA: exposed skin area (18.000 cm2 for adults; 6600 cm2 for children);
Kp: dermal permeability coefficient in water, (cm/h), 0.001 for Cu, Mn, Fe and Cd, while 0.0006 for Zn; 0.002 for Cr and 0.004 for Pb;
ET: exposure time (0.58 h/ day for adults; 1 h/day for children) and CF: unit conversion factor (0.001 L/cm3) 28.
Eq. (3) can be used to calculate the hazard quotient (HQ) of non-carcinogenic risk by ingestion pathway.

$$\text{HQ}_{\text{ing/derm}} = \frac{EXP_{ing/derm}}{RfD_{ing/derm}} \quad (3)$$

Where,
RfD_{ing} is ingestion toxicity reference dose (mg/kg/day).
An HQ under 1 is assumed to be safe and taken as significant non-carcinogenic, but
HQ value above 1 may indicate a major potential health concern associated with over-exposure of humans to the contaminants
The hazard index (HI) represents the entire non-carcinogenic risk. If the chance of not being cancerous is less than or equal to 1, it is considered acceptable; if it is greater than or equal to 1, it is considered excessive. One can determine the HI of a particular pollutant across various pathways by summing the hazard quotients using the formula in Eq. (4) below.

$$\text{HI} = \sum_{i=1}^{n} HQ_{ing/derm} \quad (4)$$

Eq. (5) calculates carcinogenic hazards for ingestion pathways. Carcinogenic risk (CRing) for the study's chosen metals is defined as the likelihood that a person would get cancer after being exposed to certain conditions in his lifetime.

$$\text{CR}_{\text{ing}} = \frac{EXP_{ing}}{SF_{ing}} \quad (5)$$

Where.
CRing is carcinogenic risk via ingestion route and
SFing is the carcinogenic slope factor.

F. Data interpretation

Microsoft Excel was used to evaluate the survey data, which were then shown as descriptive statistics in the form of tables and graphs. The experimental data was contrasted with the public health guidelines for home water use in India.

G. Outcomes

A respectable 95% of the 100 surveys that were provided were completed; only 95 of them were returned.

1) Water supply for the home.

Just 5.2% of households have water running inside of them, but many (68.7%) have their main water supply piped into their yards from the municipality. Some are forced to utilize the street public taps or get water from their neighbours' yards. When the primary water supply is disrupted (i.e., when there is no water flowing through the pipes inside the homes, yards, or public taps due to water rationing activities by the municipality, leakage of water distribution pipes, vandalization of pipes during road maintenance, etc.), the disruption typically lasts between a week and two weeks, during which time the respondents turn to other alternative sources. For almost half of the population, the return trip to the secondary water source often takes between 10 and 30 minutes.

2) Water treatment and storage methods used in homes

Plastic buckets were the most common type of container used to keep household water (n=78, 67.8%), while other containers such as ceramic vessels and metal buckets are also used. The majority of households (n=111, 96.5%) stated that their drinking water containers were covered. When it came to gathering water from the storage containers, over half (53.9%) of the respondents used cups with handles, while 37.4% used cups without handles. Merely 7.8% of families stated that they primarily boil their water before using it. About 82.6% of respondents believe that drinking water cannot make you sick, and only 17.4% are aware of the dangers of drinking untreated water. They listed specific illnesses linked to water, including diarrhea, cholera, fever, vomiting, ear infections, malnutrition, rash, flu, and malaria.

3) Sanitation procedures in households

The majority of the toilets (93.9%) have a concrete floor, while just 48% utilize the flush to septic tank system. More than half of the respondents (52%) use pit toilets. Though all respondents stated they always wash their hands with soap or any other alternative before preparing meals and after using the restroom,
over 76.5% of families do not have a specific area for hand washing.

4) Examination of Water Samples

The examinations of the water samples include physico-chemical, microbiological, and trace metal characteristics.

5) Microbiological Examination

The WHO and SANS recommended standards for drinking water were met by the samples taken from the reservoir throughout both the dry and rainy seasons, with 0 MPN/100 mL of total coliform and E. coli. Eight samples from the same source were contaminated with total coliform during the dry season, whereas seven of the eight water samples obtained from the street taps during the wet season were contaminated with the bacteria. Total coliform was found in water samples from street taps 3 and 7 in all seasons; however, the total coliform levels during the wet season were higher than the counts during the dry season. During the dry season, no sample tested positive for E. Coli; however, during the wet season, four samples from street taps were positive for the bacteria. Similar trends were observed in samples taken from household taps and street taps, with every sample being infected with total coliform during the wet season. The samples from the same sources showed a higher level of total coliform in the wet season, with almost all of the samples showing contamination at maximum detection levels of more than 2000 MPN/100 mL, with the exception of one sample (HT8) that showed a higher level of total coliform contamination. This is despite the fact that five of the eight samples collected from household taps were contaminated with total coliform during the dry season. The rainy season was associated with greater levels of total coliform in water samples from household storage containers (HSC) compared to the dry season. Additionally, more samples were infected with E. coli during the wet season. When compared to home and street taps, the HSCs had a higher level of pollution.

6) Physical-chemical Examination

The pH, EC, and TDS values in the reservoir samples varied from 102 to 141 mg/L, 161 to 232 µS/cm, and 8.12 to 8.23, respectively. Comparably, the pH, EC, and TDS values in the street tap samples varied from 7.28 to 9.33, 22 to 642 µS/cm, and 12 to 321 mg/L, respectively. The pH value ranged from 6.51 to 8.12, the EC ranged from 21 to 621 µS/cm, and the TDS ranged from 14 to 386 mg/L in the residential taps. The pH, EC, and TDS values in samples from domestic storage containers ranged from 7.01 to 7.97, 16 to 707 µS/cm, and 14 to 1071 mg/L, respectively.

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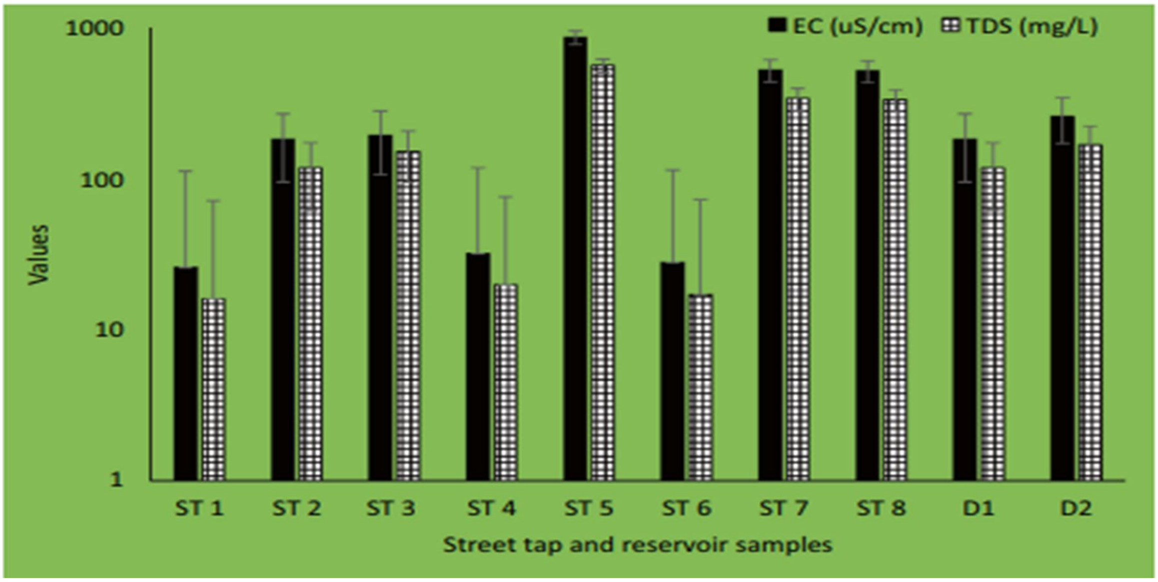
7) Examination of the trace metals and cations in Water

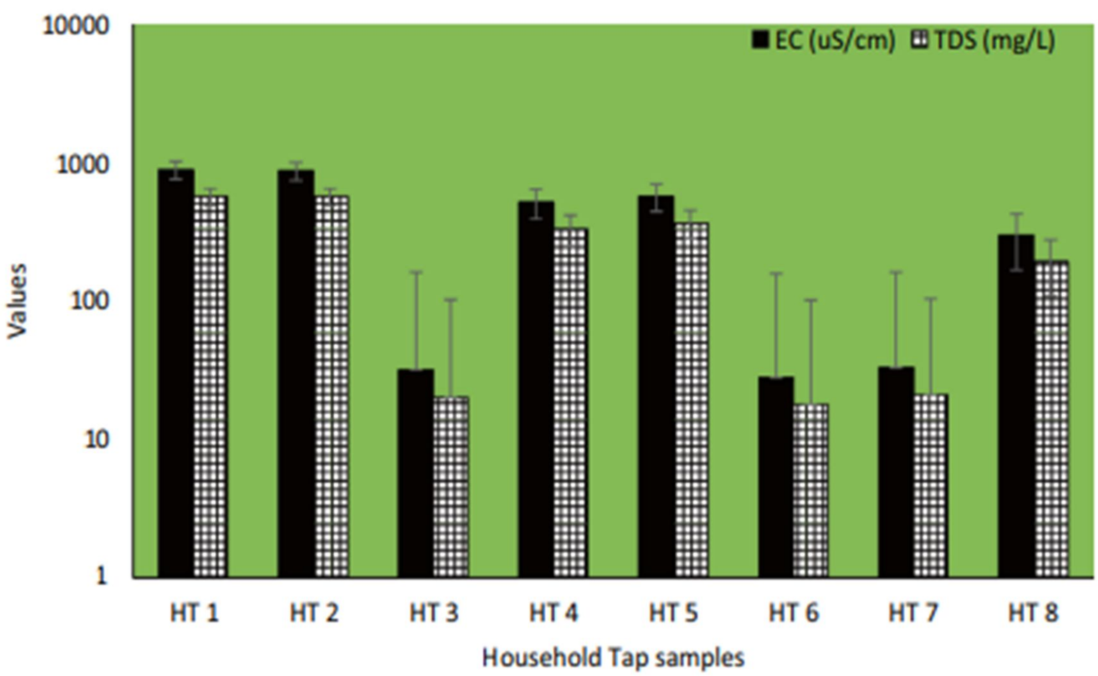
Samples from each of the sources were chosen for analysis in order to determine the amounts of cations and trace metals in the water samples. Calcium concentrations ranged from 2.10 to 22.35 mg/L, whereas potassium and magnesium concentrations varied from 0.12 to 1.67 mg/L, 1.23 to 13.21 mg/L, and 0.14 to 10.71 mg/L.

8) Examination Trace Metal

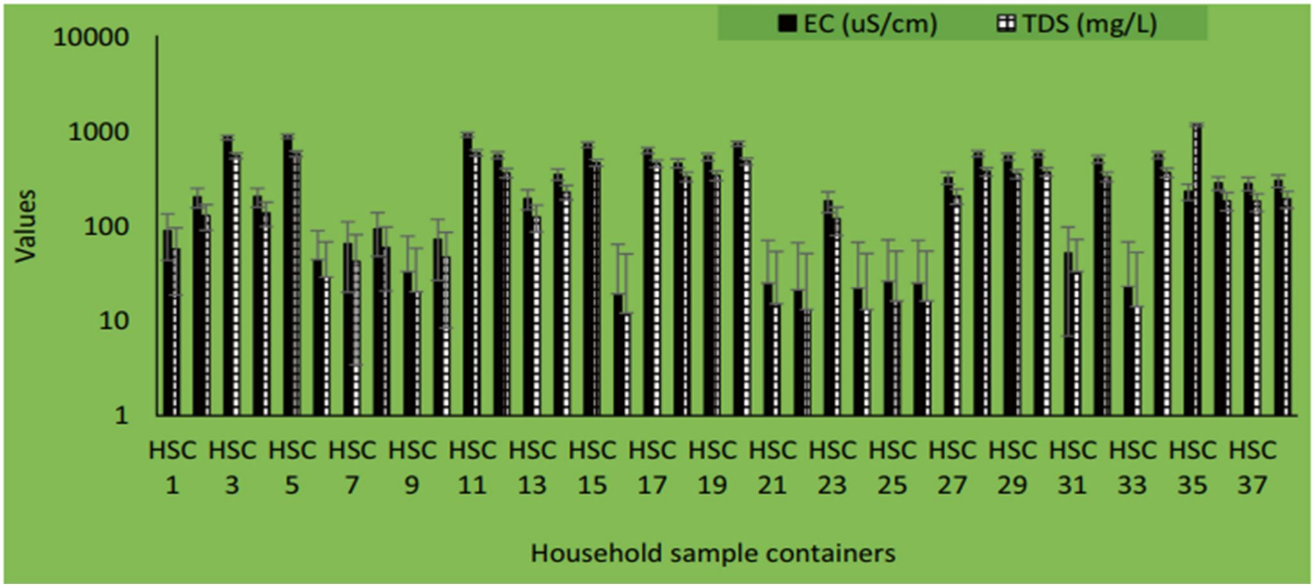
The trace metal concentrations, both lowest and maximum, of Al, Mn, Fe, Co, Ni, Cu, Zn, As, and Pb found in water samples taken from a variety of household storage containers, street taps, and taps are listed.



The street taps' and the reservoir samples' EC and TDS levels.



TDS and EC values for residential taps.



EC and TDS values for samples taken from residential storage containers

III. DISCUSSION

This study offers data on the quality of drinking water in a particular rural community in the Anatnag public health division of Kashmir, accounting for the parameters of the treated water supplied to the village by the government through the public health division, including physicochemical, microbiological, and trace metals. Few research participants had access to water inside their homes; the majority had their main supply piped into their yards. This suggests that gathering water from the yard and putting it in storage containers would be the process of obtaining water for domestic usage. Those without taps in their yards must gather water from street taps or their neighbours' yards. This observation is not exclusive to the research domain. Like people living in other Anatnag Municipality villages, people living in the study area also keep their drinking water in jerry cans, ceramic pots, and plastic buckets. The vast majority of respondents (92422%) state that their water storage tanks are covered and that, on average, their drinking water is kept in the storage containers for fewer than one week (74.3%). The chance of dust or other airborne particles contaminating water is decreased when water storage containers are covered. However, a week or longer of intermittent municipal water supply outages in the study area, along with the use of substitute water sources as a result, expose residents to a number of health risks, as intermittent water supply outages have been associated with an increased risk of distribution contamination.

IV. CONCLUSIONS

Good hygienic measures are necessary while carrying, storing, and utilizing water since the study demonstrates that the cross-contamination rate increases with distance from the treatment reservoir to distribution points. The quality of drinking water deteriorates as a result of unsanitary handling techniques used at any stage between collection and use.

Water samples from treated sources, street taps, and residential storage containers had physicochemical, microbiological, and trace metal concentrations that were primarily within the WHO and SANS drinking water standards' allowable ranges. Less than unity was the HQ for both adults and children, indicating that there is less of a health risk from drinking water for both groups. Only the maximum amount of lead for both adults and children has the highest possibility of cancer hazards among the trace metals under study.

We advise taking the necessary steps to maintain residual free chlorine at the distribution points, improving the consistency of municipal treated water supply throughout the rural communities of the Anatnag municipality in Kashmir, and providing residents with training on hygienic methods for transporting and storing drinking water from the point of origin to the point of consumption.

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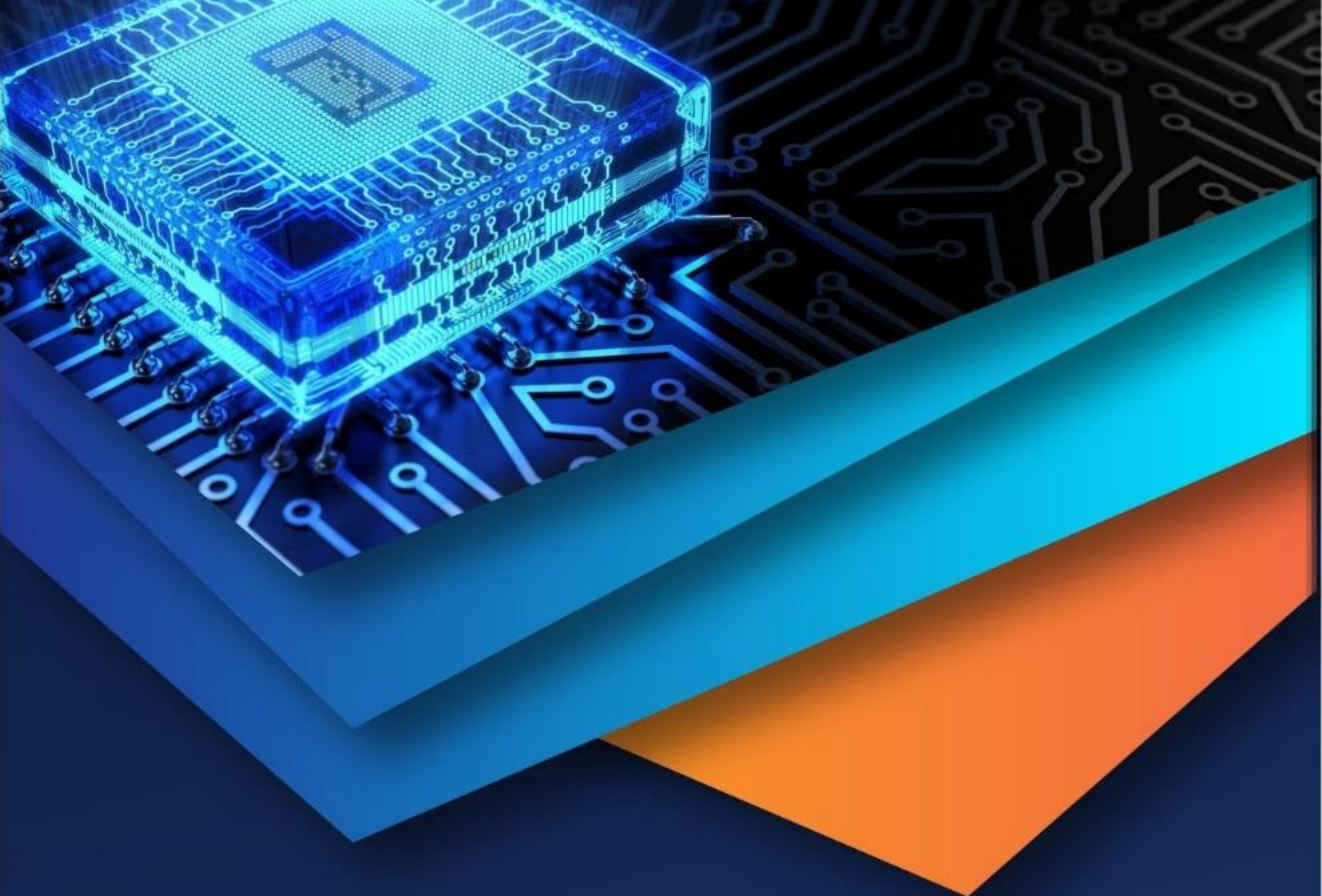

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