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Original Article

Assessment of RO Wastewater Management and Reuse: Concerning Households in Gurugram, Haryana, India

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Abstract *- As global temperatures rise, water scarcity is becoming a critical issue worldwide, impacting countries like South Africa and Brazil and cities in India such as Gurugram, the focus of this study. One significant source of water wastage is Reverse Osmosis (RO) systems, which generate 3-4 liters of wastewater for every liter of purified water. This study surveyed 143 respondents in Gurugram through a 22-question survey to gather demographic, socioeconomic, and water usage data, including RO system practices. The results revealed that 86% of respondents used RO systems, but only 45% were aware of wastewater reuse practices, and 39.8% actively reused their RO wastewater. Additionally, while 25.2% accurately knew the amount of water wasted by their RO system, 51% believed they knew. 14% of respondents would consider reusing RO wastewater if better technology were available. These findings suggest that limited technology and awareness are the primary barriers to RO wastewater reuse in Gurugram, highlighting the need for increased education on RO system inefficiencies.*

Keywords *- Gurugram, Survey, RO wastewater, Reuse, Awareness.*

1. Introduction

1.1. Literature Review

The climate crisis is an existential threat, affecting the entirety of the world's population [1]. Climate change has significantly exacerbated water scarcity issues worldwide, with glaciers, ice caps, and snowfields rapidly disappearing [2] and over 20% of the world's basins experiencing rapid flooding or rapid declines in surface water area. It is estimated that approximately 2 billion people worldwide do not have access to safe drinking water [3]. According to a WHO report, the current world population of 7.6 billion is expected to reach 8.6 billion in 2030. In April 2023, India's population surpassed that of China [4], with an estimated population of 1.425 billion [5]. As the global population grows, the demand for water increases in various sectors such as agriculture, industry, and domestic use. This heightened demand places additional stress on already limited freshwater resources, leading to water scarcity in many parts of the world.

Cape Town experienced a severe water crisis from 2015 to 2018, with critically low reservoir levels leading to the threat of a "Day Zero" when the city would run out of water [6]. Metropolitan cities in India also share the same fate. In April 2024, Bengaluru reportedly faced a severe water crisis, with an estimated daily deficit of 500 million liters, about 20% of the city's total demand [7]. Water quality assessment is essential as it allows official bodies in governments to ensure compliance with prescribed standards. Various factors affect the potability of water, including the pH, electrical conductivity, and total dissolved solids [8]. Higher TDS in water can lead to multiple health problems, as it can contribute to kidney stones, heart diseases, diabetes, and gastrointestinal issues like stomach pain and diarrhea. There are various types of water filtration systems, like ultrafiltration, ultraviolet purification, candle filters, activated carbon filters, and RO filtration. However, the RO filtration system is the most efficient as it can reduce TDS levels significantly; it has added filtration stages compared to alternatives, improves taste and safety, and is more adaptable [9]. Reverse osmosis is a water purification process that uses a semi-permeable membrane to separate water molecules from other dissolved substances.

According to a study conducted by Ranjeet Kumar and Loknath [10], 33% of households in Sharadha Nagar, Lucknow, use a reverse osmosis system to generate approximately 270 liters of wastewater per month per person. A study conducted in the Netherlands on industrial RO plants states that the Netherlands has devised a means of reusing their RO wastewater. However, the water generated from the RO usage is used for industrial activities. Gurugram is India's corporate hub and contributes to 0.6% of India's GDP [11] while housing only 0.1% of India's population [12]. The primary sources of freshwater are groundwater, water from the Yamuna River [13], and rainwater, which acts as a method of recharging groundwater [14]. Elevated TDS levels, especially in the

southwestern parts of the Gurugram district, have been observed due to the influence of the saline Yamuna River and other saline sources [15]. In a few places, TDS levels rose from 3,011 mg/liter to 5,140 mg/liter between 2016-17 and 2017-18 [16].

1.2. Significance of the Study

The average reverse osmosis system does more harm than good, wasting 3-4 litres of water for every 1 litre of potable water produced, resulting in 75% wastage of water [17]. This study analyzes the number of people consuming water in a household, water usage per person, general water usage, and wastage of RO wastewater. Currently, there are no studies about the management and reuse of RO wastewater in Gurugram.

This study aims to assess RO wastewater management practices in Gurugram City and explore the reuse potential of this wastewater as a step toward fighting the shortage of potable water and helping this area and community recover from the shortage of this fundamental human right.

2. Methodology

2.1. Selection of the Study Area

The area chosen for this study is the city of Gurugram. Gurugram is a part of the National Capital Region of Delhi and has an area of approximately 1258 square kilometers [12]. This area has been chosen as no existing studies have analyzed water usage and RO water wastage, proving to be a knowledge gap in the world of research.

In this paper, data from multiple households across Gurugram have been included to triangulate and generalize water wastage in the entire city of Gurugram, with people from multiple housing societies, such as The World Spa Sector 30, Nirvana Country Sector 50 and Orchid Island Area.

2.2. Sampling strategy

Descriptive research has been conducted to answer the research questions most suitably. A survey questionnaire was created to understand water usage, RO wastewater generation, and RO wastewater usage in Gurugram. Random sampling has also been employed, as it helps avoid bias. Gurugram is also culturally diverse, so random sampling allows less cultural skewing of results [18].

2.3. Domain of the Questions

A Google survey form was circulated via email to around 500 individuals from the aforementioned housing societies. The questionnaire was filled out by 143 individuals, which represents a response rate of 28.6%. Since the study mainly focused on studying the RO. Of the 143 participants, 40% were female, and 60% males. Most respondents, 55%, were between the ages of 36 and 50, with the next biggest age group being over 50 years old, with around 35%. The highest level of education in roughly 72.8% of the respondents was a Master's Degree. The annual household income, in INR, of the respondents was very varied, with 35% having an income greater than 100 lakh, 28% with an income between 50-100 lakh and 14.7% with income between 25-50 lakh, and the remaining 22.3% with income less than 25 lakh rupees.

2.4. Questionnaire

A total of 22 questions were asked, which fall under the following domains.

1. Demographic Data: Age, gender, Location, Type of House
2. Academic Data: Level of Education
3. Occupational Status: Profession
4. Socioeconomic Status: Range of Income
5. Overall Water Consumption and Wastage: 4 questions were asked regarding a) the number of family members, b) the number of permanent house helpers, and c) awareness of water consumption, and respondents were then asked to give d) their estimate of water used per person per day.
6. Different sources of water consumption and wastage: 3 questions were asked about a) activities that require the most water usage, b) sources of water for the household, and respondents were asked whether they had a Reverse Osmosis system or not.
7. The RO System: 8 questions were asked regarding how much the RO system was used in their house, their estimate of how much water is wasted by an RO system, whether they reuse their RO wastewater, and their awareness of how they could reuse RO wastewater.

3. Results & Discussion

The survey results on RO wastewater management and reuse in Gurgaon indicate a notable disparity between awareness and practical application. While many respondents are unaware of the environmental implications of RO wastewater, their understanding of effective reuse methods varies significantly. A considerable portion of the population lacks access to or knowledge of appropriate techniques for managing RO reject water. The data suggest that despite general awareness of the issue, challenges such as insufficient knowledge and inadequate infrastructure hinder the widespread adoption of reuse practices.

As seen in Figure 1, municipal water is the primary source of water for the majority of families, with 85.3% of respondents relying on it for their daily requirements. In contrast, just 14% of households use borewell water, which is groundwater obtained from private wells. In Gurugram, the Municipal Water Line supplies water with a TDS of 250 to 300 ppm, which is on the border of the "excellent" and "good" classifications of TDS, according to the WHO [19]. This can be seen through the study, as 86% of the respondents have an RO system in their households. The study also revealed that out of the respondents with an RO system, only 39.8% reuse the wastewater, mostly for gardening (Figure 4).

Table 1. Respondents according to location

Location	Frequency	Percentage (%)	Cumulative Percentage (%)
The World Spa	53	37.1	37.1
Nirvana Country	13	9.1	46.2
Golf Course Road	26	18.2	64.4
DLF Galleria	11	7.7	72.1
Orchid Island	11	7.7	79.8
Ireo	7	4.9	84.7
Sector-7	4	2.8	87.5
Vatika	5	3.5	91.0
Ardee City	4	2.8	93.8
Tulip Apartments	3	2.1	95.9
Sector 15	2	1.4	97.3
JMD Gardens	2	1.4	98.7
DLF Phase 3	2	1.4	100.0
Total	143	100.0	

Table 2. Age groups of respondents

Age group range	Frequency	Percentage (%)	Cumulative Percentage (%)
<18	2	1.4	1.4
18-35	12	8.4	9.8
36-50	79	55.2	65
>50	50	35.0	100.0
Total	143	100.0	

Table 3. Income level of respondents (1 lakh = 100,000)

Income (in INR Lakhs/Annum)	Frequency	Percentage (%)	Cumulative Percentage (%)
<10	5	3.5	3.5
10-15	9	6.3	9.8
15-20	5	3.5	13.3
20-25	13	9.0	22.3
25-50	21	14.7	37.0
50-100	40	28.0	65.0
>100	50	35.0	100.0
Total	143	100.0	

Furthermore, awareness of wastewater generation could also be observed through this study. An RO generates wastewater in a 1:3 or 1:4 used water to wasted water ratio. The survey asked respondents about their daily total RO water usage and wastage. Using the range input by the respondents, a ratio between usage and wastage was calculated using average range values. If the ratio was between 1:2.5 to 1:4.5, to account for inaccuracies due to range values and note continuous values (Refer to Appendix 1 for the code), it was found that only 25.2% of the respondents were aware of the true amount of water wasted by their RO, assuming that they were aware of the amount of RO water used throughout the day.

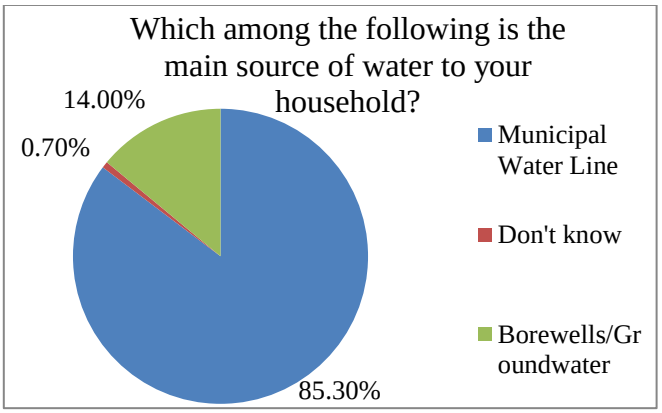

Fig. 1 Major source of Water supply to the locations under study

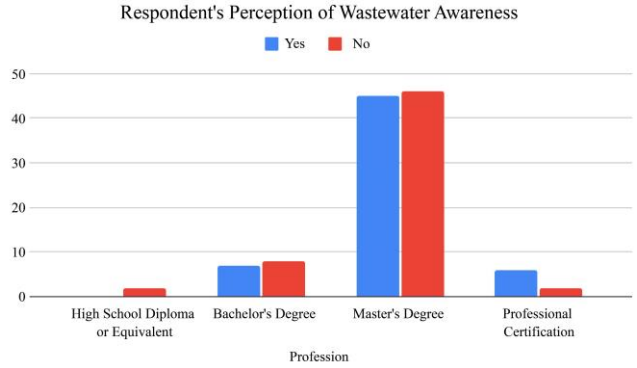

Fig. 2 Respondent's perception of awareness of RO wastewater generation based on the educational qualification of the participants

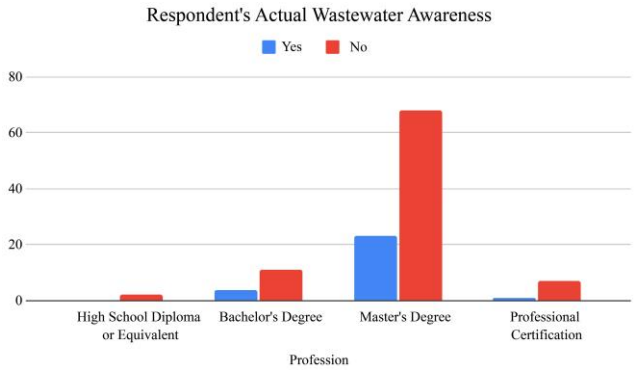

Fig. 3 Actual awareness of RO wastewater generation based on the educational qualification of the participants

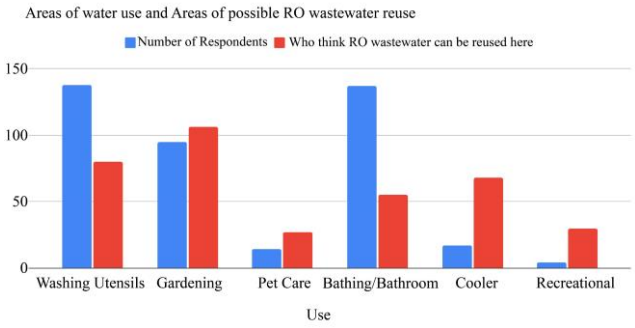

Fig. 4 The areas where water is used most V/S the areas where RO wastewater can be used

In another question, respondents were asked whether they thought they knew the amount of water wasted by their RO system, where 51% answered that they were aware of the amount of water wasted by the RO system. This shows that many respondents were misinformed about the same. The survey also showed no relationship between education level and knowledge about RO wastewater generation. Around 90% of the households reported their main sources of water usage as cooking, washing clothes, washing utensils, and bathroom water usage.

In addition, 66% of respondents reported gardening as a major source of water usage, 12% reported the cooler, and 10% reported pet care. Though only 39.8% of respondents reuse RO wastewater, all RO users were asked what plausible way to store/reuse RO wastewater. 60% felt that buckets could be used, 35%, non-exhaustive, felt that an additional storage tank could be installed, and 29% would like a central plumbing system for collection. The additional comments of the survey conveyed that over 14% of the respondents would want to implement RO wastewater reuse if there were more technologies.

Table 4. Family members of the Households using the RO purification system

Number of family members in a household	Frequency	Percentage (%)	Cumulative percentage (%)
1	4	2.8	2.8
2	18	12.6	15.4
3	30	21	36.4
4	48	33.5	69.9
5	20	14	83.9
6	10	7	90.9
7	6	4.2	95.1
8	3	2.1	97.2
9	0	0	97.2
10	4	2.8	100
Total	143	100	

An RO wastes three liters of water for every liter of water treated [17]. At the same time, the Institute of Medicine [20] recommends that a person consume three litres of water each day. In this scenario, a person needs 90 liters of drinking water per month, and RO wastes at least 270 liters for rectification if the rejected water is not reused in RO-using homes. Thus, in RO-equipped homes, 270 litres of water per person are wasted each month. The amount of water squandered grows with the number of families. To further understand RO wastewater metrics in India, findings from this survey were compared with those conducted in Sharadha Nagar [10]. 33% of RO-using households reused their RO wastewater in Sharadha Nagar, similar to Gurugram, where 39.8% reused, a difference of just 6.8%. This shows that even in smaller areas, the proportion of people reusing RO wastewater is the same, and awareness and technological solutions must be increased. Hence, people begin reusing this precious resource.

4. Conclusion

4.1. Study Conclusion

This survey-based study indicates that there is a significant knowledge gap among Gurgaon residents about the reuse of RO wastewater. Although RO systems are widely utilized in homes, most users are either ignorant of the volume of wastewater generated or do not know how to recycle it for a variety of non-potable uses properly.

4.2. Policy Review

Currently, the Bureau of Indian Standards (BIS) has issued a standard that states that no domestic water purification system can be manufactured, imported or assembled without an ISI Standard Mark or a BIS Certification [21]. This improves the quality of RO systems throughout India. However, there is a need for increased awareness of this problem.

There is a necessity for focused teaching programs and public awareness campaigns to advance environmentally friendly water usage habits. Promoting the reuse of RO wastewater has the potential to drastically cut down on water waste, which would help Gurgaon manage its water resources more responsibly as the city deals with a growing shortage of water.

4.3. Current Technologies

The reduced amount of RO wastewater reuse also calls for new technological solutions that the public can easily implement. AquaSave has created an RO wastewater collection tank with a tap attached to it so that water from the tank can be directly used for mopping, washing clothes, and washing utensils, among other uses. [22]. However, that requires the user to be mindful and remember to use RO wastewater themselves.

4.4. Limitations and Future Work

The survey was only carried out in Gurugram, limiting its applicability to other places with differing water sources or levels of awareness. The study also relies on respondents self-

reporting water usage and wastage, which may result in inaccuracies due to recall bias or erroneous estimates [23]. There was also a lack of detailed information in several circumstances.

Future studies on the topic could include conducting extensive water usage assessments in other cities, such as Mumbai or Chennai, to understand national patterns in RO wastewater reuse.

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Appendix 1:

```
water_waste_data_123 = [
    “20-30”, “10-20”, “20-30”, “10-20”,””, “10-20”, “20-30”, “<10”,””, “30-40”, “20-30”, “30-40”,
    “10-20”, “<10”, “10-20”,”>50”, “10-20”, “40-50”,””, “>50”, “10-20”, “<10”,””, “20-30”, “<10”,
    “30-40”, “<10”,””, “<10”, “10-20”, “<10”, “10-20”,””, “10-20”, “>50”, “<10”,””, “20-30”,
    “40-50”, “20-30”, “<10”, “10-20”,””, “<10”, “10-20”, “>50”, “30-40”,””, “10-20”, “20-30”,
    “<10”, “<10”, “10-20”, “10-20”, “<10”, “20-30”, “<10”, “<10”, “10-20”, “>50”, “10-20”, “10-20”,
    “10-20”, “10-20”, “10-20”, “10-20”, “30-40”, “10-20”, “30-40”, “10-20”, “>50”, “10-20”, “<10”,
    “10-20”, “<10”, “<10”, “20-30”, “<10”, “<10”, “10-20”, “>50”, “10-20”, “<10”, “30-40”,””,
    “>50”, “30-40”, “10-20”, “>50”, “>50”, “<10”, “<10”, “>50”, “<10”, “10-20”, “30-40”, “20-30”,
    “<10”, “10-20”,”>50”, “40-50”, “10-20”,””, “10-20”, “<10”, “<10”, “10-20”, “10-20”, “40-50”,
    “<10”, “>50”,”>50”, “10-20”,””, “<10”, “40-50”, “<10”, “20-30”, “20-30”, “30-40”, “<10”,
    “40-50”, “<10”, “<10”, “<10”, “20-30”, “<10”,””, “<10”, “>50”, “<10”, “20-30”, “30-40”, “10-20”,
    “30-40”, “20-30”
]

# Removing empty values and pairing water consumption with waste data
paired_data_123 = list(zip([row for row in water_consumption_data if row], [row for row in water_waste_data_123 if row]))

# Now, we’ll process the data, checking for the 1:3-4 waste ratio and calculating percentages
# Define the ranges as numerical tuples and process them
def convert_range(value):
    if ">" in value or "<" in value:
        return (float(value.replace(">", "").replace("<", "")), float(value.replace(">", "").replace("<", "")))
    else:
        return tuple(map(float, value.split("-")))

water_draw_ranges = [convert_range(draw) for draw, waste in paired_data_123]
water_waste_ranges = [convert_range(waste) for draw, waste in paired_data_123]

# Generate ‘Yes’ or ‘No’ for each respondent based on whether their waste is in the 1:3-4 range
final_yes_no_list_123 = [
    "Yes" if roughly_one_to_three_updated(draw, waste) else "No"
    for draw, waste in zip(water_draw_ranges, water_waste_ranges)
]

# Calculate percentage of “Yes”
yes_count_123 = final_yes_no_list_123.count("Yes")
percentage_yes_123 = (yes_count_123 / len(final_yes_no_list_123)) * 100

len(final_yes_no_list_123), percentage_yes_123, final_yes_no_list_123
```