2014

Unraveling the Water Demand Conundrum in Rural Punjab:

Analysis of the Socio-Economic Factors Affecting Take-up Rate of R.O. Water *

Aruna Arora

Ishu Thakur

Manisha Jain

Raj Anmol Singh Garg

Raman Goel

Supervisor: Dr. J.V. Meenakshi

* The project is part of Krishna Raj Fellowship housed at Centre for Development Economics, Delhi School of Economics. The views and the analysis expressed in the paper are those of the authors and do not necessarily represent the views of the Centre for Development Economics.

Acknowledgement

The authors of this paper are greatly indebted to the Centre for Development Economics, Delhi School of Economics for granting us the Krishna Raj Fellowship and supporting our research endeavor.

We would also like to take this opportunity to express our profound gratitude and deep regards to our mentor, Dr. J.V. Meenakshi for her exemplary guidance throughout the course of this project. We would also like to thank Prof. Anirban Kar and Prof. Sunil Kanwar for their invaluable encouragement, guidance and suggestions.

All comments/ suggestions are welcome. Please send them at:
rajanmolgarg@gmail.com

Table of Contents

Abstract

Access to safe drinking water has improved dramatically in rural India with the latest census reporting the figure at over 82.7%. However, the situation is quite grim in Punjab as indiscriminate use of chemicals in agriculture has had very serious repercussions on ground and canal water quality. Recognizing this, the Punjab government has installed R.O. water purification plants in villages, which have been expanding rapidly with near uniform coverage now. Purified water from these plants is sold at the minimal cost of Rs. 60-90 per month. However, having access to safer water does not automatically mean that households choose the safer option. This paper is an attempt to answer this water demand conundrum in rural Punjab, based on primary data collected from 179 households from 6 villages. Our analysis suggests that apart from income, other factors such as distance, awareness, publicity and other village level factors play an important role in determining the demand by households.

1. Introduction

On 28 July 2010, through Resolution 64/292, the United Nations General Assembly explicitly recognized the human right to water and sanitation and acknowledged that clean drinking water and sanitation are essential to the realization of all human rights. Waterborne diseases are a major source of mortality among infants and children aged less than five years, especially in developing countries.

India is on track to meet target 7.C of the Millennium Development Goals (Sustainable access to improved drinking water and improving sanitation facilities) as evidenced by data from the NSS 69th round (July- Dec 2012). It defines the improved source of drinking water to include: ‘bottled water’, ‘piped water into dwelling’, ‘piped water to yard/plot’, ‘public tap/standpipe’, ‘tube-well/borehole’, ‘protected well’, ‘protected spring’, and ‘rainwater collection’. During 2012, in rural India, 88.5% households had improved source of drinking water while in urban India 95.3% households had improved source of drinking water, an impressive improvement from 59.94% and 87.12% respectively in 1960’s.

However, the water situation is quite critical in Punjab, where the rampant use of pesticides and fertilizers and their percolation in soil has rendered groundwater non potable. This is coupled with the heavily polluted Sutlej waters coming loaded with industrial effluents of towns like Ludhiana, Jalandhar and Phagwara through the Rajasthan feeder canal. Contaminated groundwater causes many diseases like diarrhoea, hepatitis, arthritis and other joint problems, and even cancer due to presence of heavy metals from fertilizers, pesticides and industrial effluents which seep into the water table. Moreover, the high fluoride content also causes dental problems. Groundwater TDS (Total Dissolved Solids) ranges from 1400-9000 in the Malwa Region, way over the prescribed standards of 50-70 by WHO. In February 2013, the State Health department conducted the first door-to-door cancer survey and found that its prevalence in the southern districts is much above the national average of 80 per one lakh population. It gave credence to the widespread understanding that the cancer epidemic in these districts could be because of its contaminated waters. Incidence of cancer in Muktsar topped with 136 per one lakh, while Faridkot and Mansa reported 134 each. The Hindu, dated 25th April, 2013 reported that villagers in Faridkot observed hundreds of fishes dying in the canal, whose waters turned black for about 20 days mainly due to untreated effluents being dumped into the canals.

This has led to the government taking many initiatives, one of which is the installation of Reverse Osmosis (RO) water treatment plants under public-private partnership. Started as a pilot in 2009 in 57 villages in the Malwa region, it has rapidly expanded with about 2000 plants being currently operational. This is a membrane-technology filtration method that removes many types of large molecules and ions from water by applying pressure to it when it is on one side of a selective membrane. The impurities are retained on the pressurised side of the membrane, and pure water passes to the other side. In Punjab, water is sourced from deep submersible pumps.

While these efforts are highly appreciable, the R.O. plants have faced lots of criticism, particularly in their efficiency in removing carcinogenic heavy metals, the low percentage of people actually using it and the management of waste water from the plants and it’s the second issue which is highlighted in this study. Data from the Department of Water Supply and Sanitation, Punjab, reveals that only about 14 per cent of rural households in Bathinda and Mansa districts use RO water, which defeats the purpose of installing these plants. These figures are even lower for the rural poor.

However, since R.O. water has been established superior to other traditional water sources on all parameters of portability, the low demand for it in the Malwa belt despite the low prices charged by the village R.O plant and the high prevalence of waterborne diseases is puzzling.

World Bank experts contend that governments need to adopt a demand-driven approach in which utilities deliver services that people want and for which they are willing to pay (Fotue and Sikod, 2012). Thus, in order to ensure the efficacy of water systems set up by the government in increasing households' access to safe drinking water, sufficient knowledge about households' water demand is a prerequisite because access to safe drinking water doesn't automatically mean that households will necessarily choose the safer option.

Therefore, this empirical study contributes to that aspect as well by examining the socio economic reasons behind the households' decision of enrolling into the scheme. The study has important policy consequences since the same model for drinking water is being replicated across many other Indian states like Andhra Pradesh, Gujarat and Rajasthan.

2. Background of the R.O. water plants

The Community based R.O. water plants were introduced under the Public Private Partnership (PPP) as a pilot project in 57 villages of Gidderbaha block of Muktsar district in late 2008 when a Memorandum of Understanding was signed between the Punjab government and Naandi, a Hyderabad based NGO. On February 18, 2008 the first two plants were inaugurated in the villages of Kauni and Kotli Ablu under the 'Shudhh Jal Proyojana' Scheme. The same year in April, the project was approved to be extended to cover the state's 40 per cent rural population under the scheme in two years in 6 districts of the Malwa Region with 175 crores being funded by NABARD. In 2013-2014, 150 crores additional funds were requested by the Punjab Government to set up R.O. plants in 1166 villages where heavy metal presence was detected.

The capital cost of installing the plants are met through grants from - the State Government, World Bank, Central Assistance and NABARD. Setting up an RO plant costs about Rs10-15 lakhs. Tenders are released for the construction and operation of the R.O. plants for 7 years. After the completion of seven years, these plants are to be handed over to the respective village panchayats to run. The operating expenses (regular maintenance of the machines, electricity expenditure and the salary of the plant operator) are met through the revenues generated by the sale of monthly prepaid cards. The land for the installation of the plant is provided by the community free of cost.

It has been claimed that before building a treatment center, the organizations check the feasibility of the plant by checking whether minimum requirements are met, including adequate access to electricity and water and a potential user base of at least 500 households. They also conduct surveys and educate the villagers about the benefits for clean drinking water. Priority is given to areas with heavily polluted water where presence of carcinogens has been detected and with population of 800 households. In some large villages, two R.O. plants are installed to comfortably cover the entire population.

However, such claims appear to be off base as a mad rush is seen to install these plants in constituencies of influential ruling party politicians even where it is not required. For instance, water sampling at Phooli near Bhucho in Bathinda showed a TDS count of 800 whereas the need

for an RO plant is when the count is between 1000 and 2000. This mad rush has led to Punjab being one of the most heavily concentrated states with R.O. plants.

A major challenge faced by these RO installations for clean water is that India's ground water is getting depleted at a very fast pace because of rampant usage of the groundwater to meet the rising agricultural demand, and growing population leading to deeper penetration in the search of ground water thereby increasing the cost of plant installation. Another problem that is persistent across all RO plants is that over 60 % of water gets wasted while purifying the ground water. Presently, this waste water is either discharged into the village dirty pond (locally known as Chappad), allowed to evaporate by discharging into open fields or discharged underground, a strategy which has met with a lot of criticism.

SPEAKING STATISTICALLY

Bathinda district

PWD division number	Number of ROs installed	Enrolled users (%)	Assembly constituencies each division covers
Division 1	126	30	Bhucho Mandi, Bathinda rural
Division 2	87	26	Talwandi Sabo, parts of Rampura
Division 3	58	25	Maur, parts of Rampura
Total	**271**	**27**	

Mansa district

PWD division number	Number of ROs installed	Enrolled users (%)	Assembly constituencies each division covers
Division 1	124	38	Mansa, Sardulgarh
Division 2	113	29	Budhlada
Total	**237**	**33.89**	

Figure 1: The Tribune, 28 July, 2014

Other challenges being faced by the RO plants in most of the villages are frequent power cuts and lower storage capacity for treated water to meet demand. In some villages like Behman Diwana, the RO systems have been discontinued just after 4 years of operation. The reason cited by the sarpanch was the failure of the company officials to pay the electricity bills amounting nearly Rs 35,000; probably because of low water demand (Bhatinda Tribune, 28 July 2014). Official figures from 2014 reveal a very dismal performance of the R.O. water plants.

3. Literature Review

The analysis of the rural drinking water demand in the developing regions of the globe has been presented in various studies identifying several factors affecting the household choice of the water source. Economic literature suggests that the choice of water source is commonly influenced by household's socioeconomic and demographic characteristics and by the price of the water. Mu et al. (1990) used a multinomial logit model with the data collected from 69 households in Ukunda (Kenya). The model estimation suggests that the time taken to collect water from different sources, the price of the water and the number of women in a household influence the household's decision of the water source. Asthana(1997) through the use of a conditional logit model examines the household choice of water for rural Indian households and finds negative impacts of distance on source choice. Hindman (2002) conducted a survey of around 769 households of Cebu, Philipines and analyzed the effects of water prices, taste (as a proxy for income) and household size on the probability to choose a particular water supply source. The results indicate that the time taken to collect water from different sources (proxy of water price) has a statistically significant effect whereas the size only affect the demand for connection while taste has ambiguous effects on household choice.

Briand et al. (2009) used the data on 301 households of Dakar(Senegal), and estimate a bivariate Probit model to explain household's decision to rely on a private water connection at home or/and to get water from the public standpoint. The main findings are that the household head status as well as the quality of the supply service has a significant impact on household's choices. Also the household welfare, the education of household head, time cost, access to alternative sources, are significant enough in the household's decision to rely on private connection and/or standpipe. A cross section of 531 households was studied by Nketiah Amonsah, Woedem, & Senadza, (2009) using a multinomial logit model to identify the socioeconomic determinants of household source of drinking water in Ghana. The results confirm the influence of income, residence (rural or urban), education level of the head and the distance between the residence and water source on household choices. Luc and Fondo, (2012) also used a multinomial logistic regression model with the cross-section data of 11391 households, to find the factors affecting the household's drinking water source in Cameroon. It is found that the distance from the source has a negative impact on the water demand and other

factors like household size and the household expenditure have a strong impact on the choice of drinking water source.

Even though a lot of scientific studies have been conducted in the Malwa region regarding the water table quality and the resulting health implications, there is little literature present on the demand determinants of different drinking water sources before or after the initiative of the RO plants installation. A study by Krishnan et al. (2010), however deals with the reasons of the picking up of the similar RO plants installation in various districts of Gujarat by various private and community initiatives along with the PWD plants, understanding their management and the lifecycle costs of these plants. The findings are that the income of the households and the high price of treated water are the major factors leading to the non-consumption of water from the RO plants. Along with this, the lack of advertisement/ awareness creation by the operators or government towards safe drinking water, taste, some cultural reasons like feeling that RO water would not stay safe in the earthen pot, being content with current supply of drinking water also emerged as reasons of non-consumption from the RO plants.

Section 4: Data and Methodology

The primary motivation behind the study emerged from the abysmally low take up rate cited by various newspaper reports: both national (The Hindu 24, April 2013) as well as local. As per the information provided by the Water Supply and Sanitation Department, Punjab, three companies maintain the R.O. plants in the villages of Bhatinda and Muktsar: Naandi, S.R.Paryavaran and Doshian Solutions. All of these were contacted to share the data on the registered users with their plants. Naandi wasn't initially willing to provide the data and kept deferring, but ultimately complied after a threat of RTI. The data provided by them appeared significantly inflated, with the average take up rate going as high as 60% and in some instances, the number of registered households exceeded the total number of households. It's possible that the inaccurate data provision was perhaps to cover up poor performance of their plants in Punjab .Doshion Solutions and S.R.Paryavaran were contacted via telephone and emails but none of them responded.

A survey questionnaire was designed to capture the relevant information and was tested in Sukhna Ablu, Muktsar, which served as the pilot village. It was then streamlined to incorporate modifications in existing questions and add some new questions.

The data collected comprises of household level data from villages in Bathinda and Muktsar, Punjab. These districts were selected because they lie in the Malwa belt of Punjab and are reported to have highly polluted groundwater. Three villages in each district were randomly selected (**Bathinda**: Sivian, Jassi pauwali, Kot Shamir; **Muktsar**: Sanghu Dhoan, Udekaran, Rupana). In every village, at an average 30 households were randomly selected and surveyed. Atleast one village per operating company was selected from the list of villages and their respective R.O. plant managing companies provided by the Water Supply and Sanitation Department, Punjab; after accounting for some logistical constraints; to see if the operating company makes any difference (e.g. different companies may have different publicity strategies which can affect the take up rate). The total sample size collected is of 179 households. Data was collected on the primary source of drinking and cooking water, education, employment, demographic characteristics, awareness about benefit of RO, distance of the household from the village RO plant, wealth, reasons for consuming/ not consuming.

The personal interviews of the District Collector, village Sarpanch, water works operator and RO plant operator were also conducted to understand the district and village level dynamics.

Creation of the Wealth Index

Since income tends to be underreported, a wealth index was created as a proxy. Data was collected on the landholding size, type of dwelling (Kacha and Rented/Kacha and owned, Pakka and Rented/ Pakka and Owned), number of different consumer durables owned ((television, bicycle, car, etc.) and number of different productive assets owned (tractors and livestock).

Since almost all the households in our sample had 'Pakka and Owned' dwellings, the type of dwelling variable was dropped as there wasn't any considerable variation.

A Weighted average was then taken for each household:

$$A_n = \sum p_i q_i$$

Where q_i = Number of asset 'i' owned by the n^{th} household

p_i = Price of asset 'i' relative to the price of a T.V. (T.V. is taken as a nummeraire because 177 of the 179 households surveyed owned atleast one T.V.)

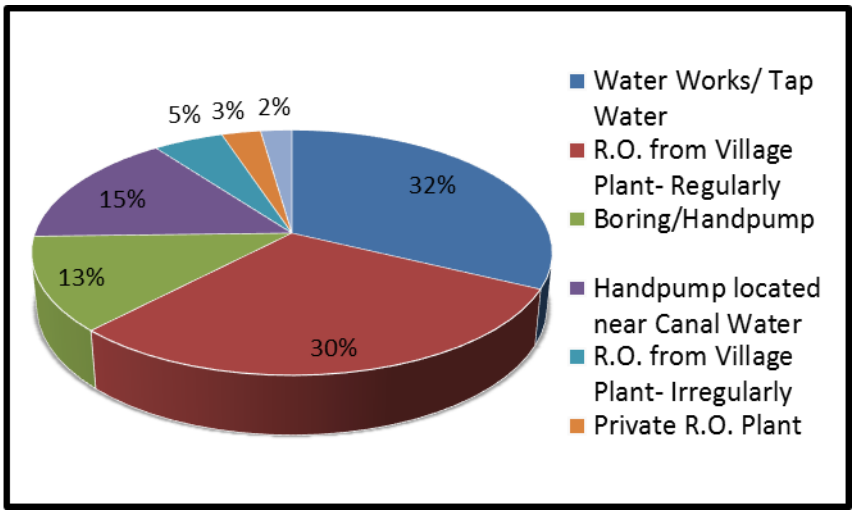
Our Max value was 522.89 and Min value was 0

Wealth index was then created to get a number between 0 and 1:

$$X\ W_n = A_n - Min\ (A_k)/Max\ (A_k) - Min\ (A_k),\ k\ \epsilon\ (1.....n)$$

5. Qualitative Analysis

A sample of 179 households has been collected and analysed in this study. The households who buy R.O. water from the village plant regularly (daily) as well as irregularly (without cards) have been classified as **Takers** of R.O. Water and the rest have been classified as **Non-takers** of RO water. In figure 2,The takers constitute **35%** of our sample and Non-takers constitute **65%.** The R.O. non-takers are dependent on various alternate sources of water some of which are common to all the villages like Water works department (tap water), and some are specific to particular villages.



(Figure 2: Primary source of Drinking water)

Common Alternate Sources of Water

- Water Works Supply:

About one- third of the respondents are dependent on the water works department supply for drinking water which are analogous to the city's municipality water supply. The Water works, figure 3, was observed to function well in some villages but residents of villages like Jassi Pauwali, Kot Shamir, and Udekaran complained that tap water was available only after a gap of 2-3 days .The Water works system present in every village supplies the canal water after filtration and chlorination to households with a connection. The water from canal is stored in

huge reservoirs (2 tanks) around 5-6 meters deep which helps in sedimentation of heavier particles. Next, this water is filtered and chlorine is added to make the water potable. An electric motor pumps the water to an overhead tank, from which water is supplied to the households via underground pipelines. The coverage varied in villages, with Rupana reporting that 100% of the households had connection to the Water works pipelines. Flat rates of Rs 100 p.m. were charged for the water connection, but as in many other parts of Punjab, Households didn't pay the bills as they expected it to be waived off anyways by the Government. This has resulted in huge outstanding bills of the Water works Department to the Electricity Department, to the tune of Rs.22 lakks in Kot Shamir

(Figure 3: Water works)

- **Hand pumps:** Besides waterworks, another major source of drinking water was Hand pumps. These can be categorized into the following:

1. Private Hand pumps located inside the house were observed in almost all households for purposes like washing clothes, etc., as a primary source or as a secondary source when there was no supply of water from waterworks Some households (13%)even used this as a drinking water source.

2. Public Hand pumps located mostly near the canal water. A general perception in the villagers was that since the location of the hand pumps was near flowing canal water, see figure 4, it tasted better than any other source. Some of the villagers in Sanghu Dhon even claimed that a team of foreign researchers and scientists had tested the water quality in a lab and obtained the same

findings (this couldn't be confirmed independently by the authors). However, in some villages it was reported that the government had blacklisted and sealed these public hand pumps due to concerns about its water quality. However, that didn't deter villagers there from ceasing to use them.

(Figure 4: Public Hand pump)

Sources of Drinking Water Specific to Villages:

Availability of these alternate sources can be thought of as an added competition to the village R.O. plants.

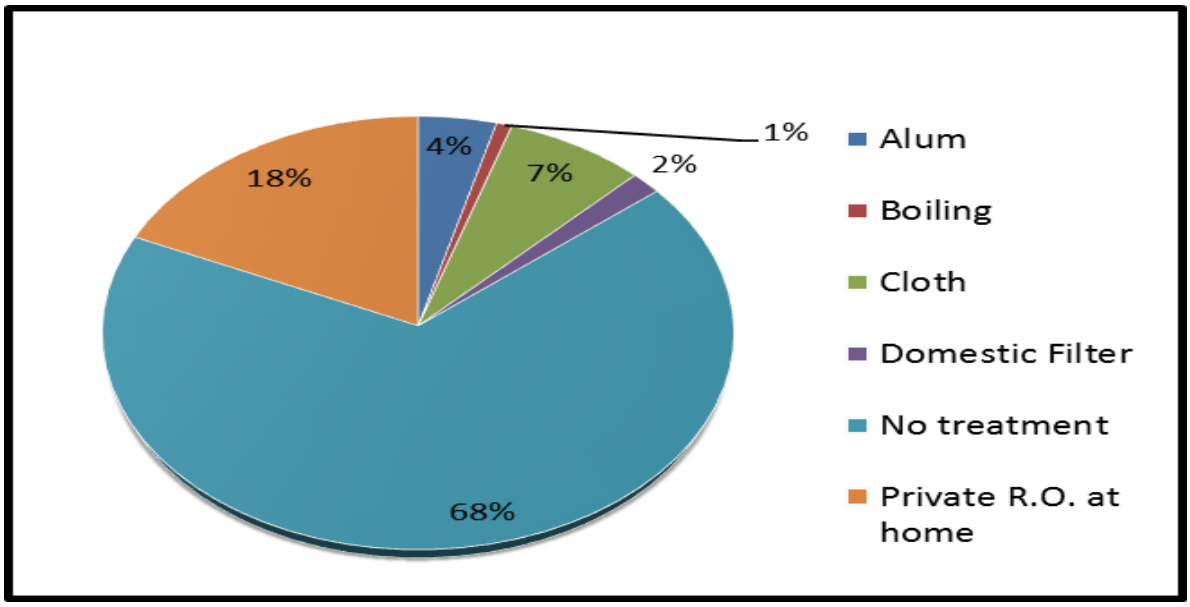
Sivian: A small R.O. plant located at the National Fertilizer Limited (N.F.L) Factory which provided free water to the villagers. The factory itself has been in operation for around 40-50 years, but the R.O. pant was set up approx. 10 years back. The N.F.L is located at the outskirts of the village which serves as a major constraining factor as to why all the households don't use it.

Rupana: A private player has set up his own R.O. plant in a nearby village which does a door-to–door delivery. Its customer base in Rupana mostly comprises of commercial entities like shopkeepers, but some households have subscribed to its services too. Since the village is very large, some respondents who were located very far from the plant took water from the public R.O. plant of a nearby village.

Purification Techniques to alternatives

The samples taken from the village R.O. plant, Groundwater and Tap Water were tested using a handheld Total dissolved solids (TDS) meter in Kot Shamir. TDS comprises of inorganic salts

(principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulphates) and some small amounts of organic matter that are dissolved in water. Even though TDS does not indicate the bacterial count in water, it is still an important overall parameter of water purity in terms of gauging the aesthetic quality of water (taste, corrosiveness, etc.) and health effects like teeth discolouring due to high fluorides presence, etc. TDS of 50-70 mg/l is considered to be the standard for safe drinking water by the WHO and the EPA has set the maximum limit at 500 mg/l.



(Figure 5: Purification applied to Non- RO. Water)

The TDS of Groundwater averaged at above 1440 ppm, which is highly unfit for human consumption. Tap water averaged at around 150 ppm, whereas R.O. water from the village plant tested for around 100 ppm.

Electrolyser is another rudimentary, cheap way of testing the water quality.

(Figure 6: Water Quality Test conducted in Kot Shamir)

Even more disheartening than the dismal Take-Up rate is the lack of any purification technique applied to groundwater/tap water. Out of the non-takers, an extremely high proportion (68%) said that they do not use any water purification methods and drink the tap/ groundwater directly, which poses a significant health risk especially in the latter case.

Some General Observations

Specification	Bathinda			Muktsar		
	Sivian	**Jassi pauwali**	**Kot Shamir**	**Udekaran**	**Rupana**	**Sanghu Dhoan**
Location	Chappad, Skewed to one end	Skewed to one end	Centre of village	Centre of village	Chappad	Chappad
Price charged (p.m.) per card	Rs 60/-	Rs 90/-	Rs 60/-	Rs 90/-	Rs 60/-	Rs 90/-
Maintained by	Doshian	Naandi	S R Paryavaran	Naandi	S R Paryavaran	Naandi
Timings	Twice a day, 2 hours each	Twice a day, 2 hours each	Twice a day, 2 hours each	Twice a day, 2 hours each	Twice a day, 2 hours each	Once a day, For 4 hours

(Table 1: Village R.O. Plants Specifications)

Plant Location

The R.O. plants are located centrally in all the villages surveyed apart from Jassi Pauwali, where it is located at one end of the village. In Sanghu Dhon, some villagers alleged that the plant was located close to the Sarpanch's house due to his political influence. In Rupana, Sanghu Dhon and Sivian the location is also adjacent to the village 'Chappad' (the local term for a dirty pond which mainly serves as the bathing place for cattle). As we will see later, 'Proximity of the plant to Chappad' emerges as one of the main reasons cited by households for not consuming water

from the village R.O. plant because of implications on the Household's perception about the R.O. water quality and taste. We raised this issue with Mr. Jaskiran Singh, the Deputy Commissioner of Muktsar District and he acknowledged that the reason the location of the plant is near the Chappad is because usually its only there that land is available for construction.

In large villages like Rupana and Kot Shamir, need of more than 1 plant was felt so as to serve households located far away from the present plant.

Price Charged

A flat rate of Rs 60/Rs 90 per card has been set by the State Government .One card can enable a household to buy 20 liters of water every day so this boils down to 10/15 paise per liter. However, there isn't any restriction on the number of cards a household can buy. Naandi revised its price of one card form Rs 60 p.m. to Rs 90 p.m. after approval from the state government a few months back. The other two companies are still charging Rs 60 p.m. It is possible that the price increase was due to insufficient revenue being generated by Nandi as it seemed to be the only operator which was concerned in proper maintenance of the plants, the other two companies were neither active nor were concerned about the maintenance of the R.O. Plants.

There are also provisions of annual cards however with a rebate of one month charges on the pre-payment of the entire amount. Apart from the card system, the operator even provides water on per day basis to the irregular consumers such as to those whose domestic RO chokes or if no other source is available. The plant also earns some income by selling 20litres plastic containers at a price ranging from Rs.150-200 but this is not binding on the villagers to consume water from the plant.

The plant is operated by a local village member generally a young guy at a fixed salary ranging from Rs.2000-2500 who opens the plant daily twice a day for two hours each. The operators do play an important role as in some villages (Udekaran) the villagers are not convinced with his

service because of his inadequate timings of operating the plant, whereas in other (Sivian) a change in the operator has led to more than doubling of the consumer base in one year.

Plant Maintenance

Laboratory reports were available at the R.O. Plants which showed the permissible limits of various parameters quality (TDS, Fluoride content, Hardness, pH, etc.) and the amounts found in the water from that plant. In some villages, the reports were regularly updated while in some the reports dated 5-6 months back. However, villagers were hardly concerned in reading these reports.

Naandi was the only company which was active in maintenance of the plants, regularly cleaning/ replacing the filters and also was the company officials were prompt to respond when there was a technical fault in the R.O. plants. They had weekly/ once in 10 days visits too for general supervision of the functioning of the plant.

In Rupana, where the plant was maintained by S.R.Paryavaran, the filter got chocked very frequently, leading to a bad taste and smell of RO water almost twice in a month.

Although the weekly or 10 days maintenance visits are made by the engineers of the plant running agencies, still there were issues regarding the maintenance as the filters of some plants were found to be choked during the survey period.

To make people switch to the RO water various publicity methods have been adopted by both the plant management and the village authorities. Regular announcements are made in the villages from the village Gurudwara (Hookah) encouraging the households to buy RO water by citing their benefits. Since the villagers did not like the taste of the RO water so in order to make them familiar with the new taste, in villages like Sivian, in the initial month of installation, the RO water was distributed free of cost to the entire village.

In the survey a stark asymmetry was found between the villagers and the plant operator regarding the specifications of the plant like the depth of the borewell or the conditions of the RO filters. The majority of the villagers were found to be unaware of the basic RO functionality and only a few educated villagers were found with the adequate basic knowledge of the poor water status in their village. While in Kot Shameer an Ex-army official showed the difference

between the Hand pump (ground water), Water works and the RO water through a TDS meter and RO Electrolyser and clearly brought out the picture of poor water quality of both hand pump and water works supply.

Further analysis is based on the Take up Rate. The **Take up Rate** hereby defined as no. of households identified as 'Takers' in a particular category divided by total number of households in that particular category

Household Demographics

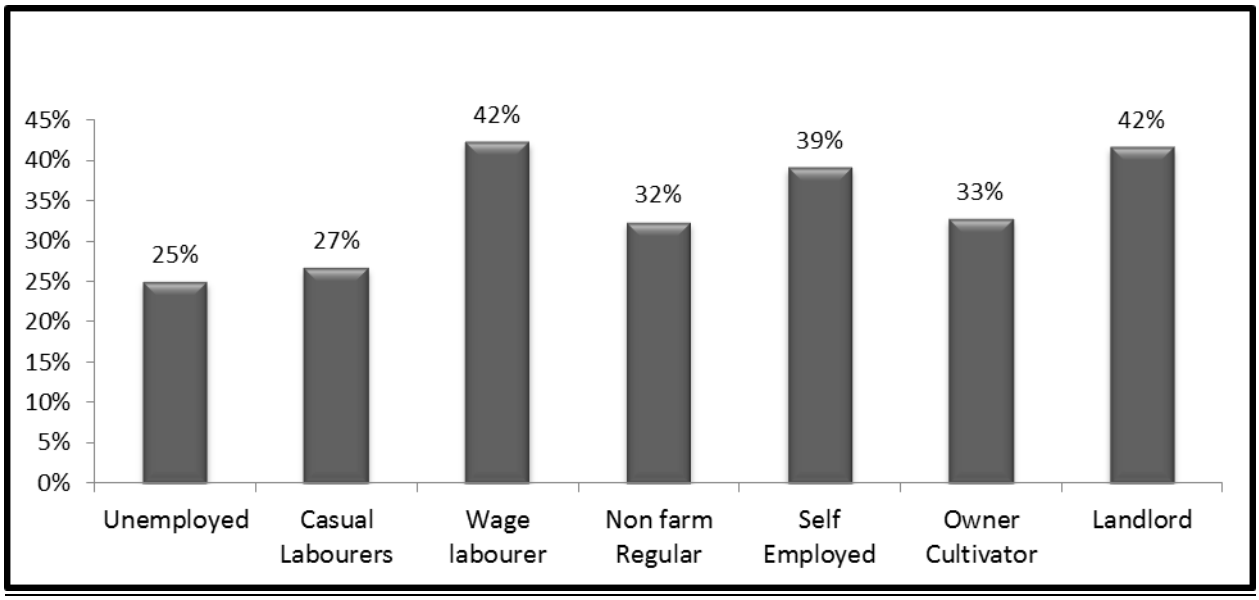
Female headed Households are expected to make better decisions regarding health issues and thus a priori, we expect a strong correlation between female headed households and takers of R.O. water. Majority of the collected data is of male headed households, with only 19 out of the 179 households being headed by a female. The Take-up rate does not vary much between these 2 categories. However, it will be unfair to draw any meaningful conclusion from this observation, because of the lack of variation in the sample in this dimension. Presence of children below 5 years resulted in a very marginal increase in the Take-up rate, contrary to our a priori belief that presence of small children will induce more informed health decisions by parents. Similarly, Proportion of Females in a household and the total number of Household members also do not affect the Take-up rate much. The average proportion of females in households taking the R.O. water was 0.45 and 0.47 for Non-takers.

Employment Status

Based on our pilot survey, the following 7 employment categories were found to be prominent: *Casual labourers* in the non farm sector, *Wage labourers* working in the farms, *Non farm regularly employed*, *Self employed*(non farm), *Owner cultivators* and *Landlords*. As observed in the figure 7 below, the take-up rate among different employment categories varies widely from 25% - 42 %. No clear-cut trend is observed here but, particularly the wage labourers, self-employed and the landlords have shown a relatively high take up rate.

- The **landlords** including from small landlords to big Panchayat members is the most prosperous and aware category of all and is likely to be a regular user of the purest water available with a very take up ratio. However, the take up ratio of 42% clearly shows the

capability of this category to get domestic RO filters installed in their homes, further confirmed by our sample.



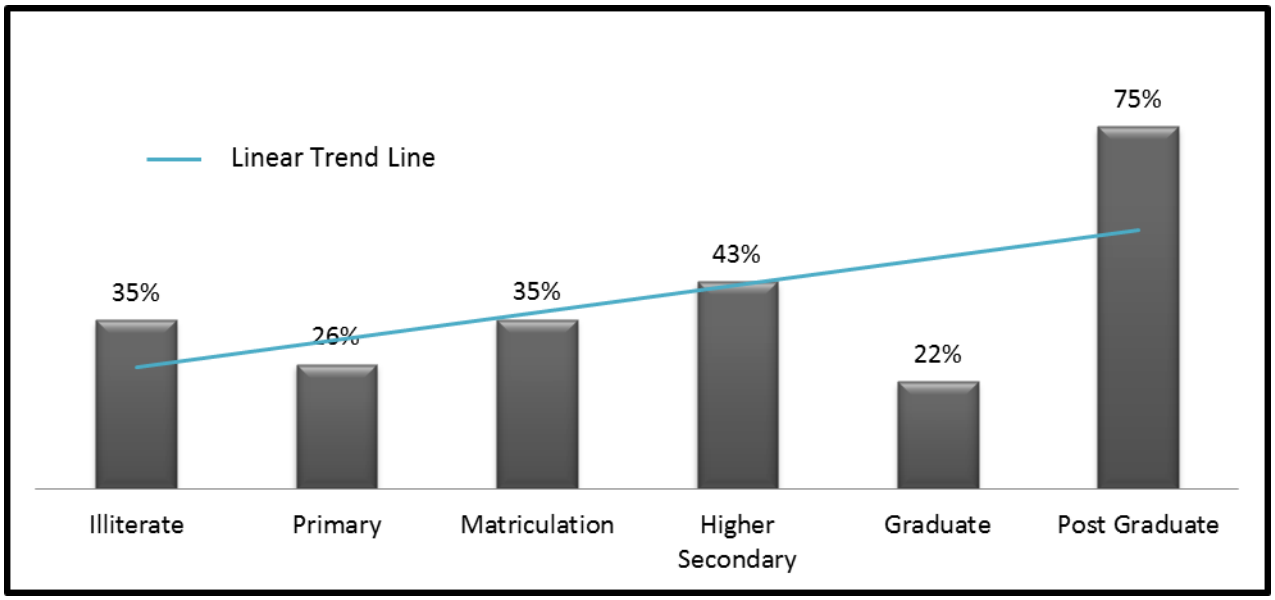
(Figure 7: Take up rate by Employment)

- The **wage labourers** on the other hand despite being at a lower income strata have shown a high take up majorly because of the inaccessibility of other reliable sources of water. The only secondary source of water with them is the water works tap connection which provides a poorer quality water and also at a gap of 3 to 4 days, which makes them depend on the plant RO water.
- The **casual labourers** share the same problem of unreliable secondary water source and the inaccessibility but however, the irregular nature of their income is not even sufficient to become a regularly customer of the RO plant.

Education

The sample is divided into 6 categories on the basis of the years of education of the household head: *Illiterate, Primary, Matriculation, Higher Secondary, Graduate and Post Graduate*. An increasing trend is observed in the Take-up Rate when plotted against the education of the

household head. As shown in figure 8, Households in which the head is a Post Graduate or above have an impressive Take-up Rate of 75% as compared to illiterate and primary level educated heads which have a take-up rate ranging 25-35%. Surprisingly, the take up ratio among Graduates is strikingly low, even lower than illiterate households. This could be due to sample biasness because households were randomly surveyed.



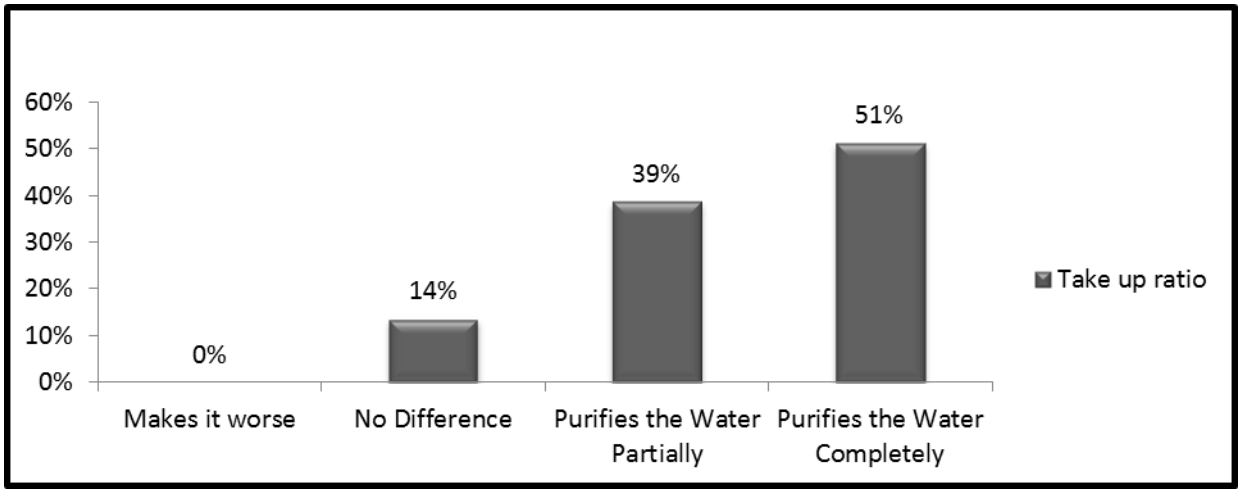
(Figure 8: Take up rate by Education)

Household's perception about water quality

Households were asked to rate the purifying ability of R.O. technology in general as *'Makes the water worse', 'No Difference', 'Purifies water partially* (Improves the Physical appearance and taste without making it safer to drink)'and "*Purifies the water completely*". Those who cited 'Makes the water worse' usually did so as they believed that the R.O. plant treated the water from the Village pond (Chappad) even though it actually treated groundwater from a depth of 150-200 meters.

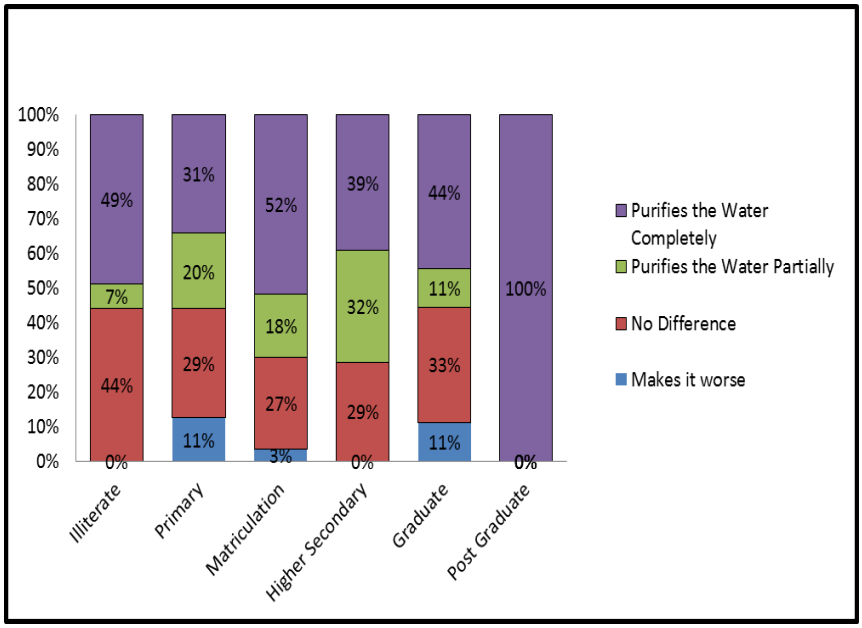
As expected, the perception about the water purifying ability of Reverse Osmosis has a strong positive impact on the take up ratio which can be seen from figure 9. The respondents who believe that RO technology purifies the water completely have a take up ratio of 51% as compared to the 14% take up rate of respondents who believe that RO doesn't make any significant difference to the water quality .

There were no reports of awareness campaigns conducted by the Government or other organizations to make people aware of the benefits of R.O. water despite the plants being installed since 2009 in some villages. A laboratory report about the results of water testing of the village plant water along with the standard permissible range of different parameters like ph, TDS, etc. was accessible at the plants, but none of the villagers actually bothered reading this. Also, in some cases, the reports weren't updated regularly.



(Figure 9: Take up rate by Perception about Quality of R.O. water)

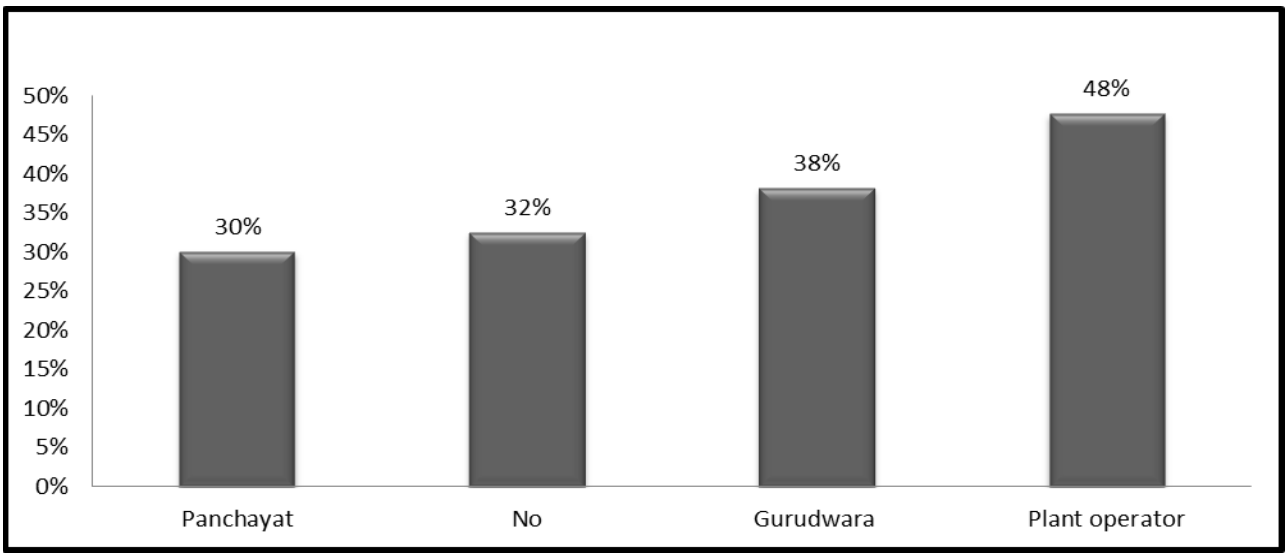
Figure 10 tries to ascertain a possible link between education and household's perception of quality of R.O. Water. Even though some anomalies are observed in the above figure, we may conclude that better education leads to better awareness about the benefits of R.O. water .44% of the illiterates believe that R.O. water isn't really different from non R.O. water , whereas all Households with a postgraduate head believe that R,O, purifies the water completely.



(Figure 10: Link between Education and Perception about Quality of R.O. water)

Publicity of the Plant

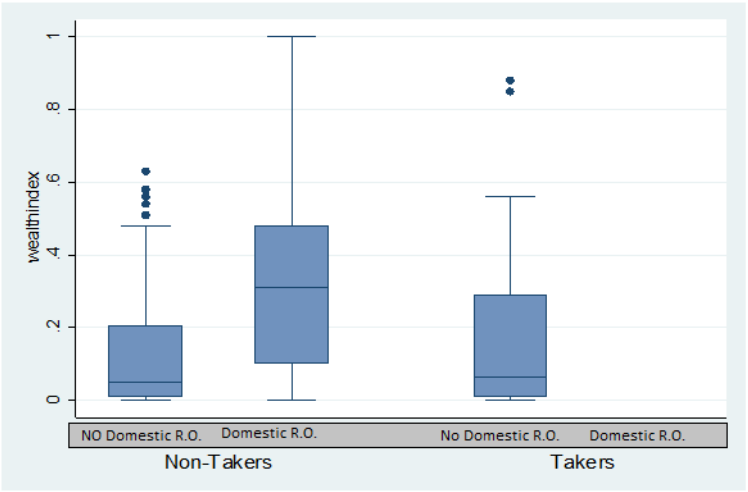
The respondents were additionally asked whether they were approached by the *Plant operator/Panchayat members/Gurudwara* about the Village R.O. Plant. Being approached doesn't necessarily mean that the households were made aware of the benefits of R.O. plant, but rather to inform and remind them about the presence of the plant, the timings, the price charged and the process of obtaining a monthly card. According to the Sample collected, surprisingly, respondents who were not approached at all had a take-up ratio marginally higher than those who were approached by the Panchayat. As we can see in figure 11 that about half of the households approached by the Plant operator bought water from the plant. The take-up ratio is higher among this category as Plant operators tend to publicize more aggressively as their job depends on this. Thus, Plant publicity is also a key determinant of the Take-Up rate. This is observed at the village level also: In villages where the plant operators and Panchayat were more pro-active at publicity of the R.O. plants (Sivian, Udekaran) the Take-up rate was higher.



(Figure 11: Take up rate by Publicity)

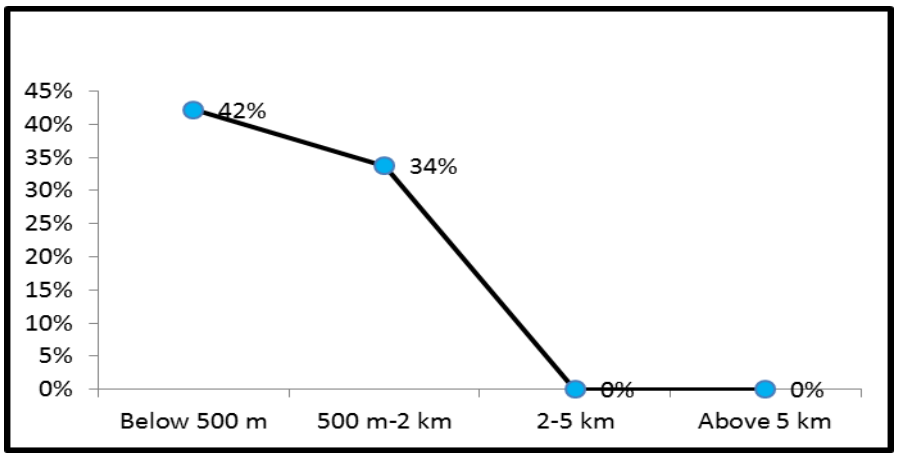
Domestic R.O.

Figure 12 below shows the Box plot of wealth index on Private R.O. In Non-takers, median of wealth index is much higher for domestic R.O. users than those who do not have domestic R.O. which is consistent with our hypothesis , as richer household are more likely to install domestic R.O. Also, We have no domestic R.O user in Takers which is also consistent, because if they have Domestic R.O. then why will they consume R.O. water from Village R.O. plant. Howver, the households, in general, lacked the knowledge about the maintainance of the domestoc RO plants, resulting in consumption of impure water.



(Figure 12: Box plot of wealth with Domestic R.O.)

Distance



(Figure 13: Take up rate by Distance)

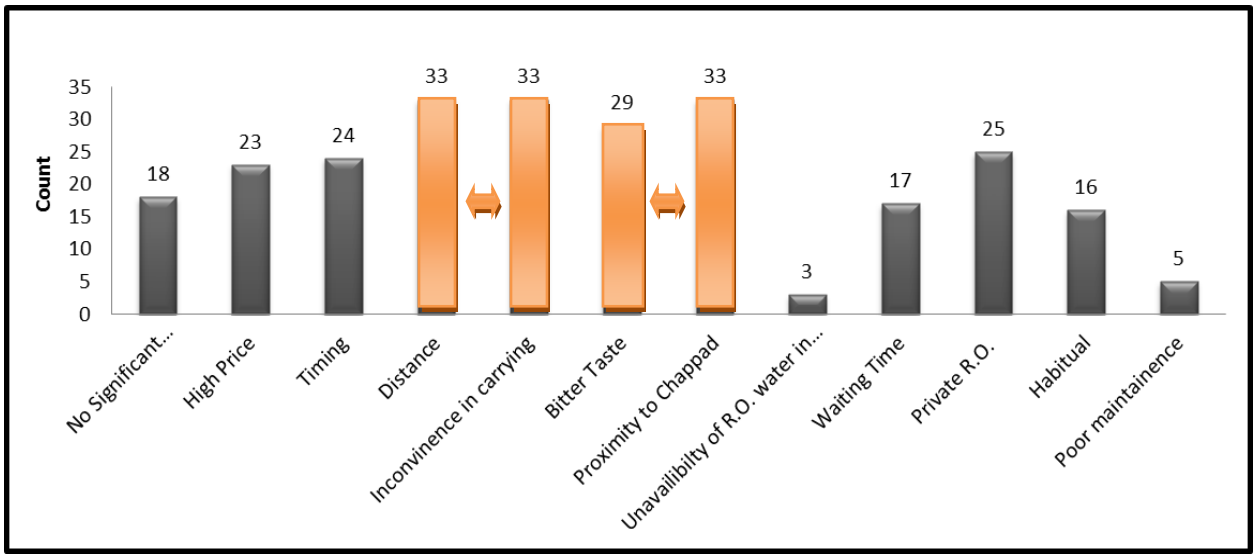
A priori, we would expect that the Take up ratio will be negatively related to the distance of the household from the R.O. plant. Figure 13 is consistent with this hypothesis. None of the Takers of R.O. water is located beyond a radius of 2km from the village plant, which highlights the importance of strategically locating the plant. In our survey, Kot Shamir and Rupana were the largest village in the respective districts and thus non-takers, there, reported distance as the major reason for not consuming.

Major reasons for not consuming water from the Village R.O. plant

In addition to the variables discussed above, the non-takers were also asked directly the reasons for not buying water from the village R.O. plant. These reasons include: *Distance, Timings of Operation of the plant, Inconvenience in Carrying 20 litre cans from the plant, Bitter Taste, Proximity to the Dirty Village Pond, High Price, Waiting time in Queue, Habitual to drinking tap water/groundwater, Unavailability of R.O. water in workplace and Poor Maintenance of the R.O. plant.*

Some of these factors are inter-related: There was a common notion that the R.O. water tastes bitter because of the proximity of the R.O. plant from the village pond or due to poor maintenance of the R.O. plant. Also inter-related are factors like Timings of Operation and

waiting time in Queue: The R.O. plants were open to the pubic only for two hours in the morning and two hours in the evening which resulted in higher waiting time.



(Figure 14: Major reasons for not consuming)

The major reasons identified for not consuming RO water from the village plants seems to be distance of the household from the R.O. water plant, Inconvenience in carrying 20 litre cans, Timing of Operation of plants for working members of the family who are not free at the time the plant is operational and therefore cannot go to buy the R.O. water and Proximity to Chappad. Having a private R.O. is also one of the key reasons due to which households don't feel the need to buy from the village plant.

These reasons differ across villages too, highlighting village specific factors at play. Some villages had additional sources of drinking water like an R.O. plant located at the N.F.L. Factory in the outskirts of Sivian which provided free water to the villagers. In Saghu dhon, a private businessman had set up his own R.O. plant which delivered water to the subscribed households.

In the villages (Sivian, Sanghu don, Rupana) in which plant is located near the chappad the villagers formed the perception that the water extracted for the purification is contaminated by the chappad water and thus tasted bitter and is impure and unfit for drinking and cooking purposes. Moreover, many villagers have even formed the wrong perception about the depth of the boring of the village R.O. plant. Thus, it is imperative to create awareness about the working of the R.O. plant by the plant operators/ Panchayat.

Villages / Reasons for not consuming	Jassi pauwali	Kot Shamir	Sanghu Dhoan	Sivian	Udekaran	Rupana
No Significant Difference/makes it worse	0%	10%	5%	17%	4%	4%
High Price	12%	0%	5%	6%	24%	10%
Timing	6%	6%	3%	15%	16%	9%
Distance	21%	23%	3%	9%	4%	15%
Inconvenience in Carrying	21%	23%	5%	8%	24%	9%
Bitter Taste	26%	16%	18%	0%	4%	9%
Waiting time	0%	0%	3%	15%	12%	6%
Proximity to Sewage water(Chappad))	0%	3%	34%	15%	0%	14%
Unavailability of RO Water in Fields	0%	0%	3%	4%	0%	0%
Private RO	0%	10%	11%	11%	12%	12%
Habitual	15%	10%	5%	0%	0%	8%
Poor maintenance	0%	0%	5%	0%	0%	4%

(Table 2: Reasons for not consuming R.O. water by village)

6. Conclusion

The paper analysed the water demand conundrum in rural Punjab, based on primary data collected from 179 households from 6 villages. To sum up, the major factors affecting a household's decision to buy water from the Village R.O. Plant or not are revealed to be the following:

1. Distance

2. Education

3. Perception about the R.O. technology in purifying water

4. Wealth

5. Plant Publicity

Given the dismal Take-Up rate and the crores of taxpayers money being used to fund the R.O. water plants project in Punjab, some remedial actions need to be undertaken so that the R.O. plants which are suffering losses can at least break-even. Door-to-Door delivery of the R.O. water at a nominal cost will overcome the 'Inconvenience in carrying', 'Distance', 'Waiting Time in Queue' and 'Timings of the R.O. plant not being suitable' factors which hinder the take-up decision of households. R.O. plants set up by private businessmen have adopted this business model, with much success in villages like Rupana. Awareness campaigns must be held in villages about the benefits of R.O. water and the health impacts of consuming contaminated water. Laboratory tests should be regularly conducted to test the water quality and these results must be made available to the villagers either by Door-to-Door campaigning or in Village melas or other gatherings. This will also help dispel away the notion of R.O. water being dirty due to its location near the Village pond.

Given the faster rate of depletion of the ground water and the fact that over 60% of the water gets wasted during purification via R.O. plants, there is a serious need to look for alternative measures of providing clean drinking water to the households.

References

1. Briand, A., Nauges, C., & Travers, M. (2009.) Choix d'approvisionnement en eau des ménages de Dakar: Une étude économétrique à partir de données d'enquête. Revue d'Economie du Développement, (3), 83-108.
2. Fotue, L. A. T., & Sikod, F. (2012). Determinants of the households' choice of drinking water sources in Cameroon. *Journal of Sustainable Development in Africa*, *14*(3), 86-97.
3. Totouom, A. L. F., Sikod, F., & Abba, I. (2012). Household choice of purifying drinking water in Cameroon. *Environmental Management and Sustainable Development*, *1*(2), p101-115.
4. Krishnan S., Indu R., Bhatt S., Pathak F.,Thakkar A. and Vadgama U. (2010) *Reverse Osmosis Plants For Rural Water Treatment in Gujarat*
5. Nketiah-Amponsah, N., Woedem, A. P., & Senadza, B. (2009). *Socio-economic Determinants of Sources of Drinking Water: Some Insight from Ghana*. Paper presented at the Conference on International Research on Food Security, Natural Resource Management and Rural Development, University of Hamburg.