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CLEAN WATER - RO SYSTEM FAILURE AND REMEDIES

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ABSTRACT

Levels of Total Dissolved Solids in drinking water supply throughout the world has been considered the baseline to judge the quality of water present in the region. High levels of Total Dissolved Solids are problematic because the dissolved inorganic salts can result in a negative health impact on members of the community. There is a particularly high level of Total Dissolved Solids found in the drinking water supply of rural Punjab, these levels were tested and the results analyzed based on the standard set by the World Health Organization. Upon analysis, high levels of Arsenic were also found to be present in the water supply in certain areas. With current projects underway by Jaswinder Mann, such as Waste Water Treatment Project, Tailing Water Treatment Project and Ash Pond Water Project. the current Reverse Osmosis facilities was investigated alongside him in rural India. Serious drawbacks were found in the working of the Reverse Osmosis system. This research project highlights the main causes of the Reverse Osmosis system failure and the necessary steps required to save the system from collapsing.

Keywords: Osmosis, Reverse, Treatment, Waste, Water

I INTRODUCTION

1.1 Benefits of the Reverse Osmosis System:

Levels of TDS (Total Dissolved Solids) and the presence of highly dangerous salts in water can be used to judge the quality of drinking water available at a particular location. When tested, the presence of a highly dangerous salt was found in Punjab.

Total dissolved solids (TDS) is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The principal constituents are usually calcium, magnesium, sodium, potassium, iron, zinc, strontium, and arsenic found as cations and carbonates, hydrogen carbonate, chloride, sulfate, and nitrate found as anions. The presence of these dissolved salts in water may affect the taste, but more so has negative impacts on health if the amounts of TDS exceed a certain limit. Based on guidelines set by the World Health Organization (WHO), water containing a TDS concentration below 1000 mg per liter is usually acceptable for consumers; acceptability may vary according to circumstances.

Many organizations have done experimentation testing the water supply throughout Punjab and made the data publicly available. This project analyzedthe data available for two villages of the rural area of Punjab. The results of the analysis of TDS and other salt levels measured per liter are presented below in Table 1. Based on the results, it is very clear that the average TDS levels (4050 mg/liter) of these two villages is much more than the acceptable WHO limit (1000 mg/liter).

The results also indicated the presence of Arsenic in the drinking water of Punjab. With reference to the data by the Government of India, Ministry of Water Resources, the ground water quality of rural district (Bathinda) shows the presence of Arsenic salt as high as 0.0287 mg/liter. This is more than twice as high as the acceptable limit of 0.01 mg/liter.

Arsenic is classified as a human carcinogen, and has the potential to cause cancer in humans. Since arsenic has been identified as a natural contaminant of groundwater, the impact it has on health and the effects have been widely studied in humans. The maximum acceptable concentration for arsenic in drinking water was established based on the incidence of internal (lung, bladder, and liver) cancers in humans, through the calculation of a lifetime unit risk.

It is very clear that the drinking water quality of Punjab, especially rural areas, is poor and a system must be put into place to prevent the negative affects of drinking water of poor quality. The Reverse Osmosis (RO) system has been proposed as a method to help filter the TDS and other salts that have a negative impact on health when in the water supply. Therefore, this paper illustrates that the RO system, or its equivalent, is a necessity for the people in the rural district of Bathinda area in Punjab. The main question that remains to be addressed is that are the RO systems installed in these villages proven to be capable of supplying clean drinking water. This paper will illustrate that there is absolutely no doubt in the capability of the RO system, but rather it is the incorrect operation of the RO equipment that has been causing the multiple reported failures of the system.

This paper will outline the correct installation and use of the RO system, and what has been found to be wrong in the installation and operation based on findings. Since the waste produced by the RO system may be highly toxic, the most effective and efficientprocedure of disposal has also been outlined.

1.2 Components Required for the Installation of the RO System:

Every generic RO system has the following nine major components that are necessary for proper installation. The lack of efficiency observed during testing has been found to be due to a problem with the last component, disposal of drain line waste product.

1.2.1 Cold Water Line Valve: Valve that fits onto the cold water supply line. The valve has a tube that attaches to the inlet side of the RO pre-filter. This is the water source for the RO system, the supply of drinking water available.

1.2.2 Pre-Filter(s): Water from the cold water supply line enters the Reverse Osmosis Pre Filter first. There may be more than one pre-filter used in a Reverse Osmosis system. Reverse Osmosis is a process, which is used to demineralize or deionize water by pushing it under pressure through a semi-permeable RO membrane. The most commonly used pre-filters are sediment filters. These are used to effectively remove sand silt, dirt, and other sediment. Additionally, carbon filters may be used to remove chlorine, which can have a negative effect on Thin Film Composite (TFC) and Thin Film Material (TFM) membranes. Other pre filters, such as Carbon pre filters are not used if the RO system contains a Cellulose Tri-Acetate (CTA) membrane.

1.2.3 Reverse Osmosis Membrane: The RO membrane is the heart of the system. The most commonly used is a spiral wound of which there are two options: the CTA, which is chlorine tolerant, and the TFC/TFM, which is not chlorine tolerant.

1.2.4 Post-Filter(s): After the water leaves the RO storage tank, but before going into the RO faucet, the water product must go through the post filter(s). The post filter(s) is generally made of carbon, either in granular or carbon block form. The purpose of this post filter is to remove any remaining tastes and odors that persist up until this point.

1.2.5 Automatic Shut Off Valve (SOV): To conserve water, the RO system has an automatic shut off valve. When the storage tank is full, this may vary based upon the incoming water pressure, this valve stops any further water from entering the membrane, thereby stopping water production. By shutting off the flow this valve also stops water from flowing to the drain. Once water is drawn from the RO drinking water faucet, the pressure in the tank drops and the shut off valve opens again, allowing water to flow to the membrane and waste-water, water containing contaminants) to flow down the drain.

1.2.6 Check Valve: A check valve is located on the outlet end of the RO membrane housing. This valve prevents the backward flow from and the forward flow of product water to the RO storage tank. A backward flow could rupture the RO membrane, therefore must be prevented at all times.

1.2.7 Flow Restrictor: Water flow through the RO membrane is regulated by this flow control. There are many different styles of flow controls available. This device maintains the flow rate required to obtain the most effective and efficient filtration to produce the highest quality drinking water, based on the gallon capacity of the membrane. It also helps maintain pressure on the inlet side of the membrane. Without the flow control, very little drinking water would be produced because all the incoming tap water would take the path of least resistance and simply flow down the drain line. The flow control is located within the RO drain line tubing.

1.2.8 Storage Tank: The standard RO storage tank holds up clean water. A bladder inside the tank keeps water pressurized in the tank when it is full.

1.2.9 Drain Line: This line runs from the outlet end of the Reverse Osmosis membrane housing to the drain. This line is used to dispose of the impurities and contaminants found in the incoming water source.

As previously mentioned, based on the analysis of available data and the experimentation performed during this project, it can be concluded that all nine components are necessary for the RO system to work, and most issues arising due to a problem with the last component, the drain line.

1.3 Observed Issues with Installation and Operation:

Rajender Singh of Tarun Bharat Sangh, Magsaysay Award winner, is called the “Waterman of India” and he says that: “The waste generated by the RO system is highly concentrated with impurities, which further deteriorates the quality of the water. This technology is a failure and should not be adopted by rural Punjab at all. Punjab needs to recharge its aquifers. The work is simple; we just need to identify aquifers in areas that are located at a height and where water quality is good. Just recharge the water there and we have water for the entire rural Punjab belt.”

(From Punjab Foundation, http://www.punjabfoundation.org/costly.html).

This has been found to be a conclusion from incorrect observation, the issue is not the RO system entirely in itself, but rather the methods of disposal of the waste filtered out.This last component of the RO system is the drain line, the purpose of which is the proper disposal of waste product. Throughout the project multiple villages were visited and it was found that impurities and contaminants rejected by the RO system are not being disposed of properly, in some cases not disposed of at all, but rather mixed with the fresh incoming water. This completely defeats the purpose of installing an RO system, since the contaminants being produced are much more concentrated than initially before filtration, allowing them to mix with incoming water makes it much more impure than prior to the RO system installation. Therefore, some observers have jumped to the conclusion that the ineffectiveness and increase in drinking water impurity is due to the installation of the RO system; these findings can be disregarded since the problem seems to be with the proper use and maintenance of just the drain line. The mixing of the concentrated waste with the incoming water supply resulted in deteriorating the quality of clean water for a few cycles.

This is illustrated and explained based on the practical example of a village. Say the village of study has a population of about 2000 people and TDS is the average based on data from two villages, Jajjal and Balluana, which is known to be 3400 mg/liter and 4700 mg/liter, respectively, therefore the average being 4050 mg/liter.

The population of the village = 2000 (approximate)

The common water tank capacity is good for all villages for 10 days. After 10 days the water tank must be refilled.

Average TDS of water is 4050 mg/liter

Efficiency of RO system installed = 96% (varying from 80%-96%)

First cycle: in the first cycle, the RO system will clean the water by 96%. This means that clean water will have TDS of 4% of 4050 mg/liter and rejected waste will increase the TDS of water in the next cycle by 96% because the rejected waste is not disposed properly, but rather is allowed to mix with the next cycle of water.

TDS of clean water = 4% of 4050 mg/liter = 162 mg/liter (Acceptable as per WHO standards and guidelines)

If this pattern of incorrect disposal of the waste is continued it is found that after the sixth cycle, the quality of water has deteriorated below the standards set by the WHO. The quality will deteriorate by each cycle and within one year the TDS of the clean water produced will become close to the TDS of the input supply water. See table 2.

Similarly, it should be noted that after the tenth cycle, the level of Arsenic salts found in the "purified" water would cross the limit of 0.01 mg/liter. The quality will deteriorate by each cycle exponentially and within two years the level of Arsenic salts in clean water will surpass the level of Arsenic in the input supply water. This finding is significant to the research because the presence of Arsenic salts beyond the prescribed limit of 0.01 mg/liter is a major cause of cancer, indicating that it could be responsible for the increase in cancer diagnoses. See table 3.

From the hypothetical, yet genuine, example illustrated above, it is very clear that after the sixth cycle, the quality of water is not fit for human consumption. In other words it can be said that if one water tank is good for 10 days, after 60 days of operation of the RO system, if the water is sampled, the samples of water will fail as per standards set by the WHO.

Based on our data analysis and results it can be concluded that within one year, the quality of clean water in the RO system will be close to the quality of input supply water as the levels of TDS in the clean water will cross 3000 mg/liter.

1.4 Future Directions for the Proper use of the RO System:

The RO system is an effective method for cleaning drinking water; the fault is not in the entirety of the system but rather the incorrect disposal of the wastebeing produced as a by-product. The issue therefore lies in what to do with the reject water, which is typically up to 20% of the RO input water volume. The simple solution, to discharge the waster into a local sewer facility is not an option because the RO reject waste has a high salinity, prohibiting disposal at such facilities. Therefore, other solutions must be considered in order to allow the RO system to be beneficial.

Mechanical Vapor Compression (MVC) Evaporators and Thermal Evaporators can be used as effective technologies for dewatering the RO reject waste streams. In brief, evaporation is a time-tested methodology for reducing the water portion of water-based waste, resulting in a more concentrated waste product. The evaporator converts the water portion of water-based waste to water vapor, while leaving the higher boiling contaminants behind. This greatly minimizes the amount of waste that must be disposed of.

The evaporation technology, is not only efficient, but has always been a more “hands-off” solution than other waster water treatment methodologies resulting in a dramatically lower labor cost as well. Therefore, as observed this solution would not only result in the appropriate usage of the RO system but would be economically beneficial to the population as well. This system can handle a much wider range of waste streams compared to membranes and traditional physical and chemical treatment methodologies. Finally, evaporation does a much better job of concentrating waste streams compared to other methods, thereby yielding a lower disposal volume and cost. By this method, the volume of waste product can be reduced by 92%.

In other countries, it has been found that reject water residual is converted into solid residual by decreasing the volume up to 92% as well. As the water level in many parts of Bathinda and Muktsar Sahib are very high, it is not recommended to dispose of this waster product into the ground, as this could result in the seeping of contaminants into the water supply. The recommended method of disposal is in special deep pits made of ceramic, to prevent further contamination of the drinking water supply. These special ceramic pits should be constructed so that no seepage occurs into the ground. Another method that can be considered to dispose of this waste product is to analyze the chemical formation and components of the waste product and utilize appropriate chemical reactions to change the product into some other final product that is not dangerous and can be easily disposed of.

II CONCLUSIONS

2.1 Conclusions and Suggestions on the Ineffective Use of the RO System in Rural Punjab:

The RO systems currently installed in rural Punjab do not have any facility with the Mechanical Vapor Compression (MVC) Evaporators and Thermal Evaporators. Without these facilities, the RO system will continue to be ineffective and inefficient. It can be concluded that these facilities are expensive and operating costs are too high, therefore it is not a feasible solution for Punjab. Rather, there are a few alternatives that are recommended and could be explored by the Punjab Government or by volunteer organizations.

1. The people of Punjab must be educated on the RO system and its use in each village. Every village has some common land and that land can be used to construct the seepage-free ponds to facilitate the natural evaporation of residual.
2. Punjab Government should also consider either the disposal of the concentrated residual at remote locations or should provide bigger seepage-free pits made of either ceramic or equivalent, that would be commonly used by three to four villages.

3. There are also many examples where the by-product can be used for better causes, as seen in Canada. For example, the Oil Sands produce Sulphur as a by-product and then this residual Sulphur is used to manufacture fertilizers. Similarly the Government should look into conducting chemical analysis on the residual waste from the RO system and should use the results to discover better uses for it.

III TABLES

Table 1: TDS and Other Salts per Liter

Location	TDS mg/liter	Fe microgram/liter	Br microgram/liter	Sr microgram/liter
Village Jajjal	>3400	200	990	1650
Village Balluana	>4700	1140	4430	6160

Table 2: Deteriorating Water Quality

Cycle Number	TDS of input water	TDS of clean water	Pass or Fail
1	4050	162	Pass
2	7938	317	Pass
3	11671	466	Pass
4	15255	610	Pass
5	18695	748	Pass
6	21997	879	Pass
7	25168	1006	Fail
8	28212	1128	Fail
9	31134	1245	Fail
10	33939	1357	Fail
11	36632	1465	Fail
12	39217	1568	Fail
13	41700	1667	Fail
14	44083	1763	Fail

Table 3: Presence of Arsenic

Cycle Number	Level of Arsenic in input water mg/liter	Level of Arsenic in clean water mg/liter	Pass or Fail
1	0.0287	0.0013	Pass
2	0.0562	0.0022	Pass
3	0.0827	0.0033	Pass
4	0.1081	0.0043	Pass
5	0.1325	0.0053	Pass
6	0.1559	0.0062	Pass
7	0.1784	0.0071	Pass
8	0.2000	0.0080	Pass
9	0.2207	0.0088	Pass
10	0.2406	0.0096	Pass
11	0.2597	0.0103	Fail
12	0.2781	0.0111	Fail
13	0.2957	0.0118	Fail
14	0.3126	0.0125	Fail

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