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DESIGN OF REVERSE OSMOSIS PLANT

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ABSTRACT : The This design project work was carried out as an attempt to design a reverse osmosis plant for providing safe drinking water to a small scale industry. It is essential to treat it suitably as the industry is in the vicinity of a chemical industry, failure of which produces a significant effect on all those consuming the water. The sample water to be treated is acquired from within the industry itself. After sample collection, two types of analysis were carried out. First was arrive to the quantity of water needed to be treated and the same was used in determining the capacity of the treatment plant. Then the collected sample was characterized in terms of pH, Turbidity, Total Dissolved solids, Total Suspended solids, Total solids, Chlorides, Sulphate, Magnesium, Calcium, COD, DO, Electrical conductivity in the laboratory as per the standard procedure. This analysis was required to propose a suitable treatment unit to purify the water. Based on the results of the qualitative analysis a suitable treatment unit consisting of an activated carbon column and reverse osmosis plant was designed.

KEYWORDS–Safe Drinking Water, TDS, RO Process.

I. INTRODUCTION

This work was to design a treatment unit for a small scale industry and to make groundwater fit for drinking. Reverse Osmosis (RO) is a process that uses semi-permeable spiral wound membranes to separate and remove dissolved solids, organic, pyrogens, submicron colloidal matter, color, nitrate and bacteria from water. The use or RO in the treatment of various effluents of chemical (Bodalo-Santoyo)[1], petrochemical, electrochemical, food, paper and tanning industries as well as in the treatment of municipal waste waters haven been reported in the literature and were studied by many researcher (Schutte)[2]. Removal of organic contaminants by RO processes was first demonstrated by (Chian)[3]. The presence of individual contaminants can cause problems, hence the removal of individual contaminants by RO has been studied by very few researchers (Murthy[4], Moresi[5], Arsuaga[6]). Murthy and Choudhari[7] studied for purification of the wastewater by removing the colour and the contaminants. A number of studies (Kimura[8], Bellona[9]&Xu[10]) have been reported on the application of RO for the removal of Organics such as endocrine disrupting chemicals, plastic additives, pesticides, pharmaceutically active compounds (PhaC's), benzene and toluene.

II. ANALYSIS OF SAMPLE GROUNDWATER:

Two type of analysis were carried out in this design work. The first type of analysis was carried out to determine the quantity of ground water fed into the plant. The quantity analysis was used to determine the capacity of the proposed treatment units. Second type of analysis carried out was qualitative analysis. The collected sample was subjected to this analysis to identify the parameters above the permissible limit for making water fit for drinking. Identification of these parameters was used in deciding the layout of the suitable treatment unit.

1.1 Quantity Analysis:

By WHO standards, ten litres of drinking water is required for each individual
Quantity needed (at present population of 50 workers) = 500 L/day
Quantity needed (at extended population of 100 workers) = 1000 L/day
$Q_F = Q_P + Q_C$
Where,Q_F – Quantity of water from ground, Q_P – Quantity of treated water,Q_C – Quantity of concentrated waste water.

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Recovery rate = 90% (Varies from 90-95%)

Recovery rate = Q_P / Q_F, 0.9 = Q_P / Q_F, Q_P = 0.9 Q_F, Q_P = 1000 L / day, Q_F = 1115 L / day.

1.2 Qualitative Analysis:

The sample ground water used for this study was collected from Patharakudi and the same was characterized in terms of pH, Turbidity, Chlorides, Sulphates, Hardness, Chemical Oxygen Demand (COD), Total solids, Total suspended solids, Total dissolved solids and Total dissolved salt, Calcium and Magnesium as per the standard tests were conducted and results are tabulated below.

S.No	Parameters	Units	Values	Standards as per BIS 10500-2012
1	pH	-	7.2	6.5 - 8.5
2	Turbidity	NTU	0.77	1
3	Total dissolved solids	mg/l	440	500
4	DO	mg/l	6.3	6 - 9
5	Total solids	mg/l	480	500
6	Chlorides	mg/l	90	250
7	***Sulphates***	***mg/l***	***385***	***200***
8	Total hardness	mg/l	85	200
9	Calcium	mg/l	50	75
10	***Magnesium***	***mg/l***	***35***	***30***
11	COD	mg/l	1800	Not desirable
12	Electrical Conductivity	mg/l	7093	Not desirable
13	Acidity	mg/l	80	200
14	Alkalinity	mg/l	10	200

Table-1 Characterization of Groundwater sample

III. DESIGN OF TREATMENT UNITS

Based on the Qualitative analysis, layout of the treatment plant was proposed. The ground water is directly fed into the activated carbon filter. GAC is used for both removing organic constituents and residual disinfectants (such as chlorine and chloramines) from water. GAC media is made from coal, nutshells or wood. Activated carbon removes residual chlorine and chloramines by a chemical reaction that involves a transfer of electrons from the surface of the GAC to the residual chlorine or chloramines. The chlorine or chloramines ends up as a chloride ion that is no longer an oxidizer. Although the total solids are less but we prefer to use Activated carbon filter to increase the life of RO Treatment plant. The membrane is designed to remove Mg^{2+} of 5mg/L and SO_4^{2-} of 180 mg/L.

1.3 Design of Activated Carbon Column:

3.1.1 Quantity of flow:

We are going to assume 1HP motor Power = ρ x g x Q x H, 745.7 = 1000 x 9.81 x Q x 12

Q = 22.8 m^3/hr (or) 547200 lit/day.

3.1.2 Activated carbon required:

Assume Recovery = 95% (Usually 90-95%)

Total dissolved solids = 0.95 x 440 = 418 mg/l

Total amount of dissolved solids = 549200 x 418 = 228.73 kg/day.

One gram of activated carbon removes 100mg of Total solids.

(From Metcalf and Eddy-McGraw Publications)

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Total amount of activated carbon = 2.29 kg
Density of activated carbon = 550 kg/m^3
Volume of activated carbon = 2.29/550 kg/m^3 = 4.16 x 10^{-3} m^3.

3.1.3 Dimensions of the column
Area x Height = Volume
$\pi d^2/4$ x 10d = 4.16 x 10^{-3}
d = 8 cm & H = 80 cm

1.4 Design of Reverse Osmosis Plant:
3.2.1 Determination of concentration of slats:
Q_F = 0.06 m^3/sec.
Concentration of Mg^{2+}& SO_4^{2-} = 120 g/mole.
Concentration of salt to be removed = 5(Mg^{2+}) + 185(SO_4^{2-}) = 180 mg/l.
Total amount of salt to be removed = 12.813 moles.

3.2.2 Osmotic pressure required:
$\pi = \phi$ x C x R x T = 3105 kg/m^2.
Concentration of Mg^{2+} = 0.417moles/m^3.
Concentration of SO_4^{2-} = 3.854 moles/m^3.
Total Concentration = 4.271 moles/m^3.
Pressure required = 1022.8 kg/m^2.

3.2.3 Flux of water:
Flux of water = 1.534 x 10^{-3} kg/m^2 sec.
Area of membrane, A = ρ_w x Q/F_w = 1000 x 0.006/1.53 x 10^{-3} = 3910 m^2.

IV. SUMMARY

This design project work was carried out as an attempt to design a treatment unit for the Groundwater sample which unless treated causes harmful health effects. The sample waste water used in this study was collected from Patharakudi, Sivagangai district. After sample collection was over two type of analysis was carried out. The first analysis was carried out to arrive the quantity of flow of water into the unit and the same was used in the determining the capacity of the treatment unit. Then the collected sample was characterized in terms of pH, Turbidity, Total Dissolved Salts, Total solids, Total Suspended Solids, Total Dissolved solids, Chlorides, Sulphates, Hardness, Calcium, Magnesium, COD in the laboratory as per the standard procedure. This analysis was required to propose a suitable treatment unit so that the Groundwater is made fit for drinking. Based on the results of the qualitative analysis a suitable treatment unit was proposed and the same was designed.

V.CONCLUSION

The analysis was carried as explained above and the results obtained was discussed below.

i. From Quantitative analysis, it may be concluded that the quantity of drinking water needed = 1000 L/day.
ii. From the Qualitative analysis, it may be concluded that the Total salts, Sulphates, Magnesium, COD were above the permissible limit as per BIS 10500 for drinking water.
iii. The proposed layout consists of Activated Carbon Column and Reverse Osmosis Plant.

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