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Treatment of RO Rejected Water at Domestic Level

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ABSTRACT: There are severe issues related to public health which are only caused by the inadequate and poor rural/urban water supply and sanitation system. Around 88% global death caused by diarrhoea is due to the inadequate sanitation hygiene and quality water supply (UNICEF, 2010). As per UNICEF, 2010 all over the world diarrhoea is the second largest cause for the death of children below 5 years, and alone India is a victim of 25% of global deaths caused by diarrhoea (WHO, 2009). Increasingly, it is been recognised that unsafe drinking water is a cause of malnourishment, leading to stunting and long-term cognitive diseases (Spears, 2013). One in every 10 deaths in India is from causes related to inadequate sanitation and hygiene (WSP, 2010). To avoid and counter this epidemic government and water supply authorities should provide drinking water as per standards listed in the Manual on Water Supply and Treatment (CPHEEO, 1999). But as per current Indian local scenario authorities are not fulfil this demand so people are investing their personal resources to treat raw water to make it potable. In domestic settings, RO is often used to remove total dissolved salts (TDS) from domestic raw water and yield permeate with relatively low TDS concentrations. While a typical domestic RO system converts raw water in a potable water but it also contributed in a huge loss of water resources, about 50 to 76% of feed water which directly goes to gutters as a rejected water; records, studies and level of treatment. This paper focus on making RO rejected water reusable or at least as a feed water using a very efficient and economic technique. To treat the RO rejected water we use GANGATIC SAND as an adsorbent to lower the TDS of rejected water, because sand is a natural adsorbent and is also very economic.

KEYWORDS: TDS(total dissolve solids, in terms of ppm), RO(domestic reverse osmosis filters), high TDS adsorption filter(aka adsorption filter), GANGATIC sand(normal ganga sand from Gandhi Ghat, Patna).

I. INTRODUCTION

Nearly 70 per cent of India's population lives in rural areas. Of the 121 crore of all Indians, 83.3 crore live in rural areas while 37.7 crore live in urban areas, as per the Census 2011. The level of urbanisation has increased from 27.81 per cent in the 2001 Census to 31.16 per cent in the 2011 Census, while the proportion of rural population has declined from 72.19 per cent to 68.84 per cent. Needless to say, providing drinking water to such a huge population with different physical, socio-cultural and economic backgrounds is an enormous challenge at hand. Pollution of water bodies because of increased use of pesticides/fertilisers, natural lithographic setting like soil, rock, or aquifers etc. and effluents from industries, most of which are beyond the direct control of the implementing agencies of the States. RO system is the most preferred filtration technique to treat raw water for making it potable domestically, commercially and industrially, RO is the opposite of the natural process of osmosis. In Reverse Osmosis, the natural process of osmosis is reversed: by using high pressure, pure water is forced to flow through the membrane from the concentrated side to the more dilute side. As per report by, "TRANSPARENCY MARKET RESEARCH" on 2017, the various technologies available in Indian water purifier market are gravity filters, RO purifier, UV purifier, sediment purifier and water softener. The RO technologies held a lion's share rate of about 37% of total market in terms of revenue, in 2015 (figure 1). The three end users of water purifier technologies are the households, industrial and commercial sector. In 2015, the household segment alone accounted for a share of 55% of the overall user segment. Analysts anticipate that water softener technologies will register continuous growth as growing number of consumers as the rural India will incline towards using these technologies.

India Water Purifier Market, by Technology, 2015 (US\$ Mn)

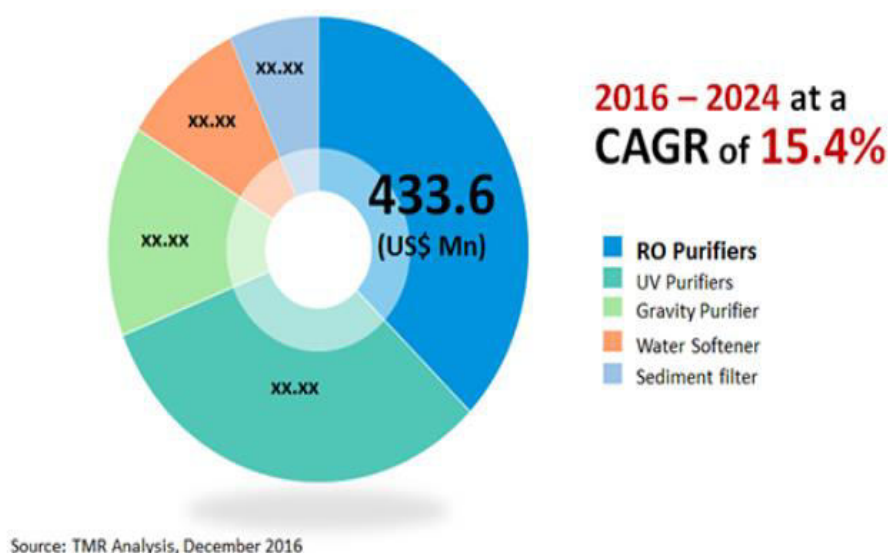


Figure1: Market size distribution of various type of filters

(Source: Transparency market research, published jan-2017)

1.1 A comparison between input and output of RO

A comparison between quantity between feed water, rejected water and produced water and their respective TDS concentrations are listed in Table-1.

Table-1: Input output rates of RO filter at different recovery rate along with it's TDS level

Recovery rate	15%	25%	40%	60%
Source Water Flow (Litters Per Minute)	500	300	187.5	125
RejectFlow(Litters Per Minute)	425	225	112.5	50
Product Water Flow (Litters Per Minute)	75	75	75	75
Source Water TDS (ppm)	3000	3000	3000	3000
Product Water TDS (ppm)	500	500	500	500
Reject Wastewater TDS (ppm)	3029	3500	4500	7000

(Source: Reverse Osmosis is not a Viable Option for Water Purification in Water Stressed Regions of India.Lalit Mohan Sharma and Rashmin Kaur Joshi)

As seen in above table-1 in a higher recovery RO system, less water is rejected. However, the concentration of pollutants increases with increasing the recovery rate. Figure-2 illustrates the adverse effect of high TDS and high volume of reject water at various recovery rate scenarios.

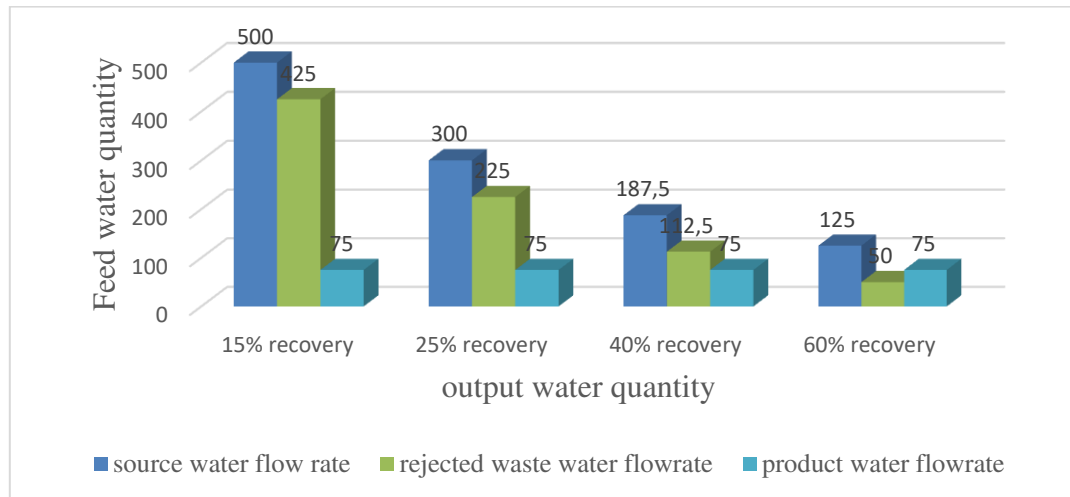


Figure 2: Variation of input and output and rejected rate of RO filter at different recovery rates

There are no efficient methods to treat RO waste/rejected water in an efficient way which can be implemented on a domestic level. There is a strict need to treat RO rejected water in an efficient and in an economical way, implemented in every small and large scale RO plant.

II. MATERIALS AND METHOD

Installation of filter has been done in the civil engineering department of NIT PATNA near water resource lab, behind the water cooler. Feeding of raw/RO rejected water to be done directly from rejecting outlet of RO filter and the other batch experiments performed in the environment engineering lab of NIT PATNA

The project is performed in the three stages

1. Checking of water quality parameter.
2. Batch experiments: Done in the environment engineering lab of NIT PATNA.
3. On site experiment: Installation of adsorption filter at site and making it operational.

In the 3rd stage of experiment so called On Site Experiment, there is a recirculation of filtered RO rejected water through the TDS adsorption filter, to reuse the RO rejected water. Flow diagram of adsorption filter is given below Figure 3.

Flow diagram of adsorption filter:

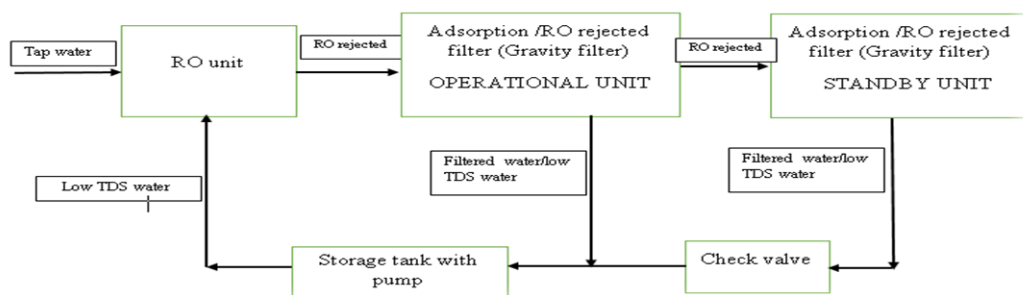


Figure 3: Flow diagram of adsorption filter



2.1 Used apparatus, chemicals and performed tests

Here we used the adsorbent method to lower the high total dissolved solid (TDS) of RO rejected water and the material used as an adsorbent is GANGATIC SAND which passed through 1.19mm (No.16) of standard sieve. List of essential items is given below-

1. Treated and untreated adsorbent (GANGATIC SAND)
2. Earlanery flask of 250ml, 8-10 in numbers at a time
3. BOD shaker at medium shaking facility
4. Spectrophotometer for sulphate testing
5. Muffle furnace to treat the adsorbent (GANGATIC SAND)
6. Fluoride meter for fluoride testing
7. TDS meter for TDS measurement
8. Fabricated Filter

2.2 Selection of adsorbent:

We are looking for a very efficient and economic technique to treat the rejected water in which no extra power/energy or waste to be use or generate. In the above dissection we observed that the various techniques used requires power consumption and waste generation which is very hazardous and challenging task to treat eco-environmentally and requires further implementation of energy and resources which is uneconomic. Sand is a natural adsorbent and can be further enhanced as an effective adsorbent on the basis of treatment implemented on it, so we choose GANGATIC SAND to use as an adsorbent due to the following properties-

- Easily available
- Economic
- Inert
- Due to very low binding property, this sand have no use in construction practice which makes it available in abundant.
- Free from organic matter
- Uniform in size (free from clay)
- Transportation was easy

Above listed property makes GANGATIC sand a suitable adsorbent material for the project purpose.

2.3 Treatment of adsorbent

To treat the sand first of all it is sieved with 1.19mm (No.16) sieve to remove the organic matter and lumps of clay which are rarely present and then washed with deionized water and then sun dried. Treatment of sand is, keeping it at 100⁰c for 18hrs and at 200⁰c for further 6hrs.

2.4 Specifications of adsorption filter

2.4.1 Adsorption filter of following dimensions and specifications (figure-4)

- I. Material ISA 35x35x5
 - II. Covering sheet (five sides) of 60 gauge
 - III. Plan area 50x50 cm.
- I. Height of filter 80cm (70cm filter media height plus 10cm tank height at bottom of tank) plus 5 cm stand, and free board of 5cm from the top of adsorption filter.

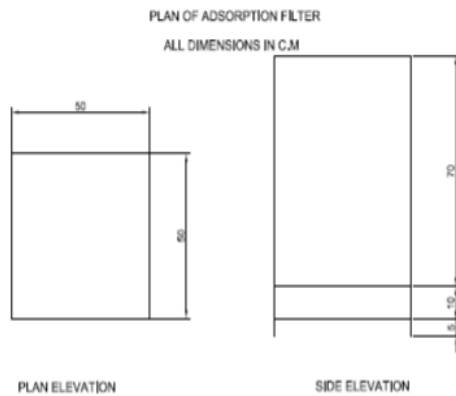


Figure 4(a)



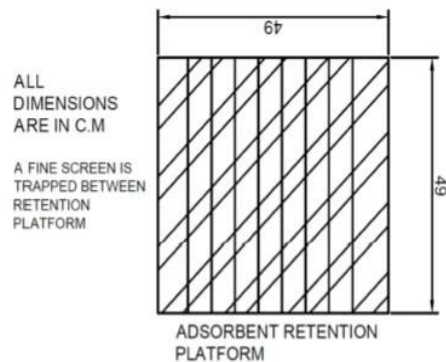
Figure 4(b)

Figure 4: 4(a) and

4(b) represents plan elevation and actual picture of adsorption filter

2.4.2 Retention bed of adsorption filter following specifications (figure-5).

- I. Double perforated segment at a height of 10 cm from bottom in which screening/net is trapped to prevent the passage of filter media.
- II. Plan area of 49x49 cm.



5(a)



5(b)

Figure 5: 5(a) and 5(b) represents the plan and actual cross-section of retention bed of adsorption filter



2.5 STAGE-I

2.5.1 Checking of water quality parameter

Water quality parameters of RO feed water: Ro feed water is the normal tap water which is stored into ta water tanks pumped through the ground source (table-2).

Table-2: water quality parameters of RO feed water

Parameter	Concentration
pH	7.49
Temperature	28.06
Cond.(μ s/cm)	555
Acidity(mg/l)	56.63
Alkalinity(mg/l)	125.68
DO(mg/l)	6.85
Hardness(mg/l)	148.46
T.D.S (ppm)	352 \pm 2
Sulphate(mg/l)	10.06
Nitrate(mg/l)	3.01
Fluoride(mg/l)	1.0
Chloride(mg/l)	70.89

2.6 STAGE-II, BATCH EXPERIMENTS:

2.6.1 TREATMENT WITH TREATED ADSORBENT (GANGATIC SAND):In this stage different dose of treated adsorbent is mixed with 100ml of rejected RO water sample and left in shackd and unshackled conditions and tested for different water quality parameters after 24hrs(Table-3).

Table-3: initial and final TDS level after treating with treated adsorbent

Prepared samples		TDS(ppm)		Percentage removal/ efficiency(%)
Treated adsorbent(g)	Rejected water(ml)	Initial	Final(after 24hrs)	
2.0	100.00	402 \pm 2	245 \pm 2	39.05
5.0	100.00	402 \pm 2	196 \pm 2	51.24
10.0	100.00	402 \pm 2	179 \pm 2	55.47
15.0	100.00	402 \pm 2	185 \pm 2	53.98
20.0	100.00	402 \pm 2	184 \pm 2	54.00
25.0	100.00	402 \pm 2	186 \pm 2	53.60
Average final TDS = 195.83 \pm 2				51.22%

Now the graphical presentation of dose of adsorbent vs TDS removal efficiency of batch experiment-A taking % removal of TDS on Y-axis and adsorbent dose on X-axis (Figure-6)

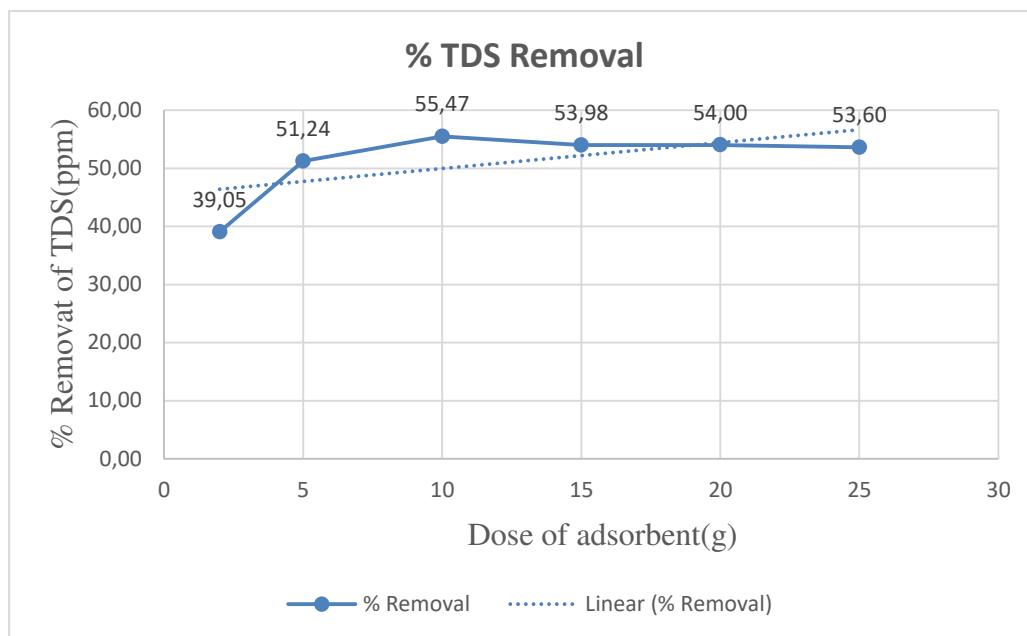


Figure 6: Variation of TDS at different dose of treated adsorbent

2.6.2 TREATMENT WITH UNTREATED ADSORBANT: In this stage different dose of treated adsorbent is mixed with 100ml of rejected RO water sample and left in shackled and unshackled conditions and tested for different water quality parameters after 24hrs (Table 4).

Table-4: variation of TDS at different dose of untreated adsorbent

Prepared samples		TDS(ppm)		Percentage removal/ efficiency(%)
Untreated adsorbent(g)	Rejected water(ml)	Initial	Final(after 24hrs)	
2.0	100.00	402±2	277±2	31.08
5.0	100.00	402±2	273±2	32.08
10.0	100.00	402±2	226±2	43.78
15.0	100.00	402±2	233±2	42.03
20	100	402±2	232±2	42.80
25	100	402±2	236±2	41.20
Average final TDS = 246.16±2				38.82%

Now the graphical presentation of dose of adsorbent vs TDS removal efficiency of batch experiment-B taking % removal of TDS on Y-axis and adsorbent dose on X-axis (figure-7)

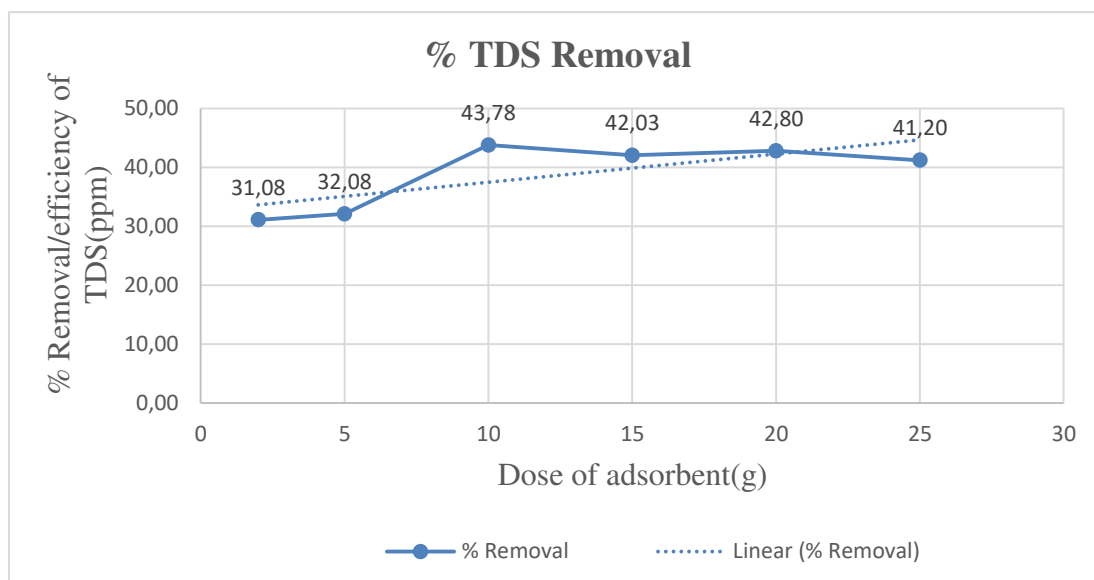


Figure 7: Graphical variation of TDS at different dose of untreated adsorbent

2.7 STAGE-III

2.7.1 ON SITE EXPERIMENT: Installation of adsorption filter at site and making it operational.

Mechanism of RO filter: Inflow, outflow, rejection rate etc. of RO filter is listed below (Table-5).

Table 5: Mechanism of RO filter

Parameter	Value
Recovery rate	62.5% @ 2200ml/min
Rejection rate	37.5% @ 667ml/min
Inflow TDS	402±2 ppm
Outflow TDS	220±2 ppm

$$\begin{aligned}
 \text{Rejection rate} &= [(\text{feed TDS} - \text{product TDS}) / \text{feed TDS}] \times 100 \\
 &= [(352 - 220) / 352] \times 100 \\
 &= 37.5\%
 \end{aligned}$$

$$\begin{aligned}
 \text{Recovery rate} &= (100 - 37.5)\% \\
 &= 62.5\%
 \end{aligned}$$



2.7.2 Mechanism of adsorption filter: Inflow, outflow, rejection rate etc. of RO filter is listed below (Table-6).

Table 6: Mechanism of adsorption filter

Parameter	Value
Inflow rate	667ml/min
Outflow rate	400ml/min
Plan area	50x50cm ²
Total height of filter	80cm
Depth of bottom tank	10cm
Height of filter media	65cm
Specific gravity of filter media	2.68
Size of filter media	Passed through sieve No.16
Inflow TDS	402±2 ppm
Outflow TDS	220 ppm (See below table)

Outflow TDS of adsorbent filter is not constant but is fluctuating with time. After filling the adsorption filter with filter media and rejected water (to be filtered) up to the mark we left it for 24hrs undisturbed for the development of schmutzdecke which means “dirt layer” in German. The purpose to let the development of schmutzdecke to counter or to minimize the organic matter entered while operational period of adsorption filter. Starting of noting down the continuous reading of TDS at regular interval of 24hrs of outflow of the adsorption filter was done (Table-7)

Table 7: Variation of TDS level of output of adsorption filter at 24hrs interval

Day/ Date (@4PM)	TDS(ppm) of outflow from adsorption filter
Day 1; 26/04/2019	402
Day 2; 27/04/2019	333
Day 3; 28/04/2019	286
Day 4; 29/04/2019	249
Day 5; 30/04/2019	221
Day 6; 01/05/2019	210
Day 7; 02/05/2019	209
Day 8; 03/05/2019	207
Day 9; 04/05/2019	206
Day 10; 05/05/2019	209
Day 11; 06/05/2019	212
Day 12; 07/05/2019	215
Day 13; 08/05/2019	217
Day 14; 09/05/2019	219
Day 15; 10/05/2019	222
Day 16; 11/05/2019	248
Day 17; 12/05/2019	313
Day 18; 13/05/2019	332
Day 19; 14/05/2019	361
Day 20; 15/05/2019	402

Taking average value of day 2nd to day 19th of outflow TDS of adsorption filter which is 223ppm. This daily variation of TDS is plotted in graph taking TDS concentration on Y-axis and time interval on X-axis (Figure-8).

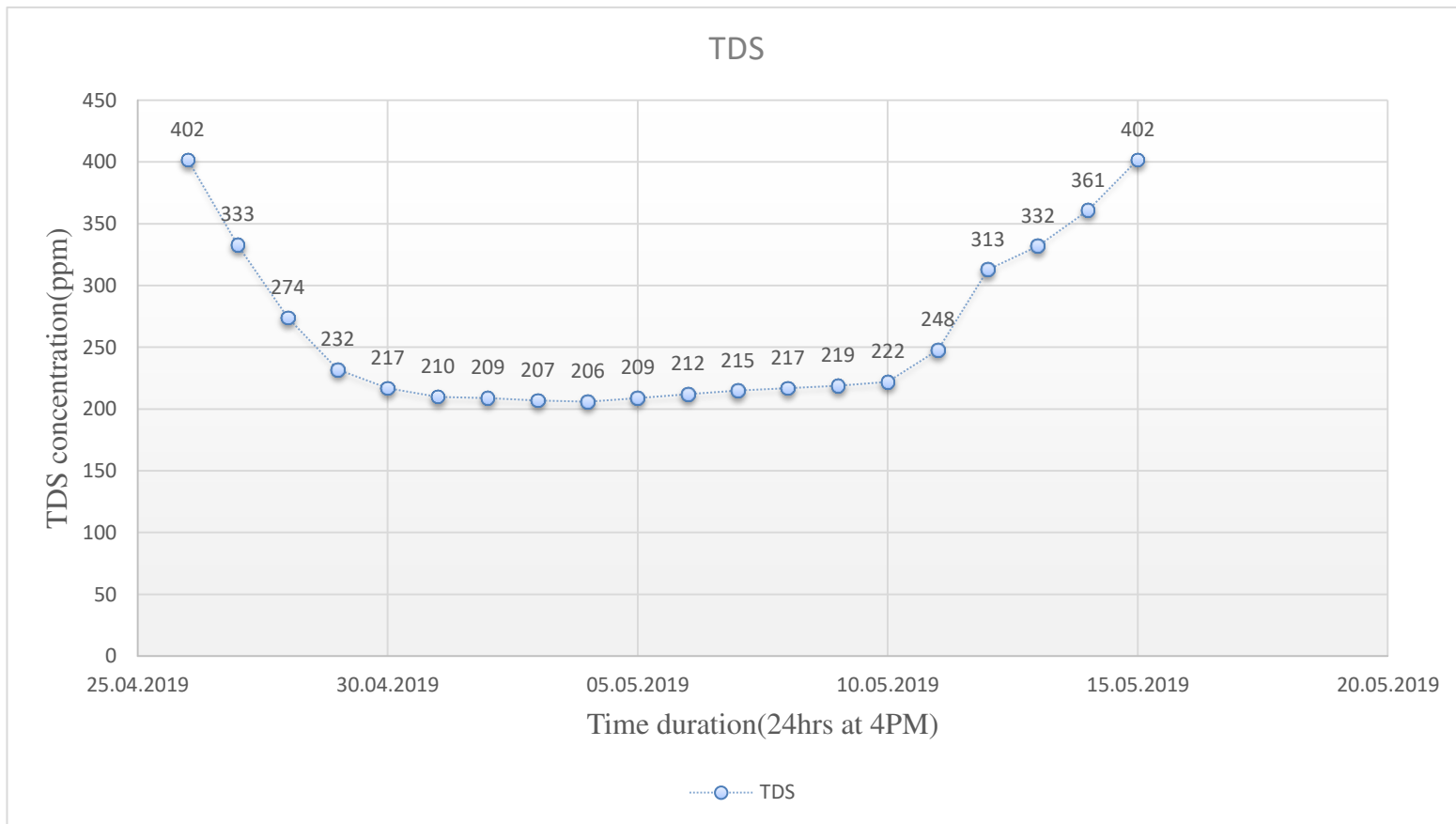


Figure 8: Variation of TDS level at outlet of adsorption filter at 24hrs interval

III. RESULT AND DISCUSSION

3.1 Result from batch experiment of treated adsorbent:

Parameter	Before treatment	After treatment
TDS(ppm)	402±2	186±2

Efficiency with treated adsorbent = $[(\text{initial TDS} - \text{final average TDS}) / \text{initial TDS}] * 100$
 $= [(402 \pm 2 - 195.83 \pm 2) / 402 \pm 2] * 100$
 (Efficiency) = 51.28%

Efficiency of batch experiment = 51.28%

From the table-3 it is observed that the optimum dose of treated adsorbent is 10g per 100ml.

3.2 Result from batch experiment of untreated sand

Parameter	Before treatment	After treatment
TDS(ppm)	402±2	246.16±2

Efficiency with treated adsorbent = $[(\text{initial TDS} - \text{final average TDS}) / \text{initial TDS}] * 100$
 $= [(402 \pm 2 - 246.16 \pm 2) / 402 \pm 2] * 100$
 (Efficiency) = 38.76%

From the table-4 it is observed that the optimum dose of treated adsorbent is 10g per 100ml.



3.3 Result from adsorption filter

Parameter	Value
Efficiency	62.5%
Rejection rate	37.5%
Inflow rate	667ml/min
Outflow rate	400ml/min
Inflow TDS	402±2 ppm
Outflow TDS	220±2 ppm

Rejection rate = [(feed TDS-product TDS)/feed TDS]x100

= [(402-220)/402]x100

= 45.27%

Efficiency/Recovery rate of TDS = (100-37.5)%

=62.5%

Efficiency of adsorption filter is varying with respect to time, optimum efficiency occurs at the mid of operational period (20 days).

IV. CONCLUSION

During the operational period of adsorption filter there is a problem of clogging of filter because of increase in head loss. To regenerate the filter media (adsorbent) washing of media with 1% HCL solution was done. Optimum efficiency of adsorption filter occurs during the mid of operational period (operational period is nearly about 16 days) and the optimum dose of treated and untreated adsorbent is 10g/100ml, which gives the maximum TDS removal efficiency. About discharge rate 667ml/min from RO filter which was being wasted is now further reusable as RO feed water. This efficiency can be further improved if treatment of adsorbent is to be done on the chemical grounds.

REFERENCES

1. Ardini, F., Magi, E. and Grotti, M., 2011. Determination of ultratrace levels of dissolved metals in seawater by reaction cell inductively coupled plasma mass spectrometry after ammonia induced magnesium hydroxide coprecipitation. *Analytica chimica acta*, 706(1), pp.84-88
2. Satish., 2016. Disposal of Reverse Osmosis Reject Water for Achieving Zero liquid Discharge (ZLD)
3. WHO Library Cataloguing-in-Publication Data, Progress on Drinking Water and Sanitation: 2012 Update 1. Water supply – standards. 2. Potable water – supply and distribution. 3. Sanitation 4. Millennium Development Goals. 5. Programme evaluation, I. WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation. ISBN: 978-92-806-4632-0 (NLM classification: WA 670) ISBN: 978-924-1503297 Printed in the United States of America
4. Al-Ghamdi, A.A., 2017. Recycling of Reverse Osmosis (RO) reject streams in brackish water desalination plants using fixed bed column softener. *Energy Procedia*, 107, pp.205-211.
5. Prasad, G., Rajput, R. and Chopra, A.K., 2006. Sand intermittent filtration technology for safer domestic sewage treatment. *Journal of Applied Sciences and Environmental Management*, 10(1), pp.72-78
6. Virapana, R. Saravananeb, and V Murugaiyanb., (2017). Treatment of Reverse Osmosis Reject Water from Industries. Volume 12, pp. 489-503
7. Lalit Mohan Sharma and Rashmin Kaur Joshi., (2010). Reverse Osmosis is not a Viable Option for Water Purification in Water Stressed Regions of India.
8. <https://www.transparencymarketresearch.com/india-water-purifier-market.html>



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