A case study - Reuse of Domestic Waste Water for industrial purpose

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ABSTRACT

Because of not having access to a safe water supply and sanitation affects the health of 1.2 billion people annually (WHO and UNICEF, 2000). Water is a very precious source and also basic requirement for survival of mankind. So it is necessary to meet with requirement of water availability according to increase in population. Appropriate 'BALANCING ACT' would be 'RECYCLE and REUSE' of wastewater. This will bring water back for use rather than disposing it considering as a 'waste'. In this paper, case study of domestic sewage treatment plant at Vadodara City is discussed. Treatment on secondary effluent treatment plant shows acceptable quality for reuse for industrial purpose. Coagulation, flocculation, sedimentation, filtration, ion exchange, chlorination treatments are tried in sequence and for application design are provided for reuse of waste water.

Keywords: domestic waste water, treatment, reuse, design

1. INTRODUCTION

1.1 Reuse of domestic waste water

Reuse of treated sewage after necessary treatment to meet industrial water requirements has been in practice for quite some time in India. Disposal of sewage from the rapidly growing cities of India has become a nightmare for civic authorities and planners. Untreated domestic waste has become the single most important reason for the spread of water borne diseases. The common problems with urban area are urban sewage mismanagement, lack in treatment facility, correct data is not available, infrastructure is collapsing, treatment is ineffective, very costly, poor recovery of cost and centralized functioning is a problem. To meet the water requirement of a particular region, sewage is the constant and reliable source which cannot be ignored. Reuse of waste water for the purposes like agricultural activity, gardening, flushing, industrial reuse can be a common practice to save the freshwater resources.

1.2 Scenario of Gujarat

The per capita water availability in the state is considerably low and is likely to go down further by 2025. Therefore, the state needs to focus on the effective planning and management of its water resources. With the urban water needs being higher than that in rural areas, and Gujarat being an urbanized state, the demand and supply ratio may get skewed in the future according to the government's own estimate. B.N.Navalawala.(2005)

1.3 Feasibility & Necessity Of Reuse Of Water

Wastewater reuse strategy for industries is a cost-effective solution. It is an alternative to act upon when industries are affected with resource depletions and variability of the water quality. The notion of unlimited water availability is unreal. Therefore for any industry using water for the production, the sources of water are seawater, or industrial and municipal effluents. Waste water consists only 1% impurities and 99% water. So if this water is reused, it has large environmental and socio-economic benefits. In all urban areas of the state, this water can be reused in an easy manner and used for industrial and horticultural purpose. If water reused is done in urban areas of Gujarat, the value of water made available for use could be as high as Rs1,800 crore per year. So it is feasible to opt for the option of reuse of waste water in central Gujarat region. More than 29% of the total number of households in Gujarat receive untreated drinking water, reveals the data collected during Census 2011. The present study being carried out is for the feasibility study of the treated effluent from the sewage treatment plant for the reuse purpose for some of the industries at nearby area of domestic effluent plant, and the treatment of waste water for common effluent treatment plant for agricultural purpose in nearby area.

2. LITERATURE REVIEW

To ensure sustainable and successful wastewater reuse applications, the following requirements must be fulfilled:

- The potential public health risk associated with reuse of wastewater are evaluated and minimized;

- The specific water reuse applications meet the water quality objectives.
- In order to meet the requirements, it is necessary to treat the wastewater prior to reuse applications,
- Ensure an appropriate level of disinfection to control pathogens.

These alternatives range from doing nothing to modifying the supply or the demand variable in the supply-demand relationship. The reuse or recycling of urban waste water in many circumstances may be an economically attractive and effective management strategy for extending existing supplies of developed water, for providing additional water where no developable supplies exist and for meeting water quality effluent discharge standards.

Until the beginning of the 1990s management of water resources which includes wastewater treatment was mainly a technically dominated issue in the engineering domain. The economics of reuse of wastewater in irrigation, little work has been done before the mid-1990s. Moore, Olson and Marino (1985) provide a detailed assessment of on-farm economics of reclaimed wastewater irrigation in California. Dinar and Yaron (1986) analyze the optimal treatment of municipal wastewater before its reuse for irrigation purpose. Haruvy and Sadan (1994) provide a nation wide cost and benefit analysis for Israel. Haruvy et al. (1999) determine monthly optimal treatment levels and of the mix of crops calculated to maximize agricultural incomes, according to farmers' point of view. Among the literature on IWRM the conceptual approaches to wastewater management with focus on the reuse of wastewater are represented byHarremoes (1997), Huibers and van Lier (2005), Nhapi, Siebel and Gijzen (2005), van Lier and Huibers (2007), Neubert (2009) and Guest et al. (2009).

2.1 Public Perceptions And Acceptance

For successful implementation of reuse schemes, public acceptance is a very important (Asano, 2001; Po, Juliane & Nancarrow, 2004; Marks, 2004; Marks, Martin &Zadoroznyj, 2006; McKay &Hurlimann, 2003, Jones, 2005) [1] parameter that tendency of people to be motivated by a set of long-term goals, but to act in the short term towards those things that they control, is what affects wastewater reuse projects. According to Robinson and Hawkins (2005),public concerns about real or perceived risks are weighted against the use of reclaimed water. Po, Juliane and Nancarrow (2004) have identified the following factors to influence community's acceptance of the reuse scheme:

- Disgust or 'yuck' factor,
- The perception of risks associated with using recycled water
- The specific uses, cost of recycled water
- The sources of water to be recycled,
- Issues of choice,
- Trust and knowledge,
- Attitudes toward environment,
- Socio-demographic factors.

2.2 key Objectives For Water Reuse Concepts

E. Huertasa*, M. Salgota, J. Hollenderb, S. Weberb, W. Dottb, S. Khanc,d, A. Schäferd, R. Messaleme, B. Bisf, A. Aharonig, H. Chikurelg," 2006 Scientists working closely on the issues of water reuse are far from having solved all concerns related to the practice. From the very beginning of a water reuse project, scenarios must be prepared from the 'zero scenario' (no reuse) through to more complex and expensive ones (e.g. reverse osmosis for potable water treatment) to help the stakeholders to select the best option for increasing available water resources, the ultimate purpose of reuse

2.3 Waste Water Reuse In India

For ages, the marginalized communities in India have relied on the indirect use of wastewater to grow vegetables, fruits, cereals, flowers, fodder (van derHoek et al., 2002). The Musi River in Hyderabad is one such river, where around 250 households within the city use wastewater directly from drains or from the river to irrigate their lands (Buechler, De vi &Raschid, 2002). One of the latest crises of modernity is water scarcity. It has been established that this crisis is not a true water scarcity problem but a crisis of governance (Rogers & Hall, 2003; Colebatch, 2006; McKay, 2007b). More recently, wastewater management and use is considered seriously as an integral part of water management policy in many water-scarce countries. Wastewater from point sources, such as the sewage treatment plants and industries, provides an excellent source of reusable water and is usually available on a reliable basis, has a known quality, and can be accessed at a single point (Davis &Hirji, 2003). Urban wastewater use reduces the amount of waste discharged into watercourses and hence improves the environment. It also conserves water resources by lowering demand for freshwater withdrawal (Khouri, Kalbermatten&Bartone, 1994). Though it is believed that wastewater reuse can augment freshwater supplies, and help communities accrue substantial benefits, institutions and individuals leading the way in the wastewater treatment and sanitation have often ignored the practice of wastewater reuse and its implications.

In addition, the development of sustainable water reuse schemes often encounter technical, financial, commercial, regulatory, policy, social and institutional impediments (Davis &Hirji, 2003; Thiyagarajah, 2005; Dimitriadis, 2005).The potential benefits of water recycling,water conservation have been identified as two of the greatest challenges of our time (Dimitriadis, 2005). Most wastewater reuse studies in the past have adopted a scientific and biophysical approach (Buechler, 2004) and the dearth of institutional studies using a combination of social, quantitative and qualitative methodologies impedes the formulation of recommendations that could enhance the benefits and ease the concerns of all groups involved with wastewater reuse.

3. DATA COLLECTION

Out of the total available domestic effluent plants in central Gujarat, the Atladra sewage treatment plant, Vadodara City is selected looking to the availability of the data. The sewage treatment plant selected for the study is 43 MLD sewage treatment plant, with a technique of UASB (upflow anaerobic sludge blanket) a Modern State of Art, which was started by Vadodara Municipal Corporation in 2001.Sewage treatment plant receives about 32 % (i.e.70 MLD) of the sewage generated by the city covering about 35 % city area. A 53 MLD new sewage treatment plant is installed in 2010 for meeting the requirements of the treatment.With the commissioning of this treatment plant in year 2001, rest of the capacity out of 70 MLD i.e 43 MLD of sewage is treated by means of advanced treatment based on UASB technology, with treated sewage meeting the Gujarat pollution Control Board norms. The various sources contributing to the wastewater to this new 43 MLD STP are as follows:

- Domestic wastewater from the west zone (drainage zone III) of City.
- Industrial effluent from the cluster of industries.

4. METHOFDOLOGY

The experiments and designing works carried out for exploring the possibility of reuse of the treated sewage water for industrial uses is done as follows:

- Sample Collection.
- Analysis of the Samples
- Treatability Studies on the sample collected
- Basic Designs

Table 1: A Detailed Characterization Of The First Average Sample Collected Form Secondary Outlet

Parameters	*Sample 1.1*	*Sample 1.2*	*Sample1. 3*	*Sample 1.4*	*Sample1. 5*	*Sample 1.6*	*Sample 1.7*	*Average Value*
PH	7.8	8	8.65	8.25	8.8	8.5	8.7	8.38
D.O.	6	5.8	6.8	4	5	6	7	5.8
Temp.	25.6	25.9	25.8	25.12	25.10	25.8	25.10	25.9°C
Turbidity	12	16	14	18	22	20	24	18 NTU
T.S.	728	730	715	744	727	729	731	729
T.D.S.	695	700	690	992	698	696	694	695
S.S.	34	20	25	30	48	43	38	34
T.H.	249	249	250	252	254	255	254	252
C.H.	472	472	477	469	472	467	475	472
C.O.D.	30	34	38	42	50	54	46	42
B.O.D.	17.5	18	18.5	19	18.5	19.5	18.5	18.5
Sulphate	51	53	54	53	57	55	53	53
Phosphate	5.2	5.2	5.1	5.2	5.3	5.4	5	5.2
Chlorides	120	123	127	130	124	124	126	125
NH3-N (Ammonical Nitrogen)	33	33	35	35	30	37	36	34
Org. Nitrogen	23	23	29	29	24	27	27	26
MPN	>1600	>1600	>1600	>1600	>1600	>1600	>1600	>1600
Total Bacterial Count	34250	34250						34250

4.1 Treatment to waste water

4.1.1 Coagulation, Flocculation and Sedimentation

In addition to fine suspended matter, wastewater also contains electrically charged colloidal matters, which are continuously in motion and never settled down under the force of gravity because of stability forces like electrical double layer, charge intensity and water of hydration. To find out the optimum dose of coagulant jar test was done. Here the sample in amount of 500 ml was taken in beakers of two liter and alum was added in varying dose to find out the optimum dose. The added amount was noted. The rotation of paddles was kept between 30-40 rpm. (@ 37 rpm) for 30 min. Then the flocs formed were allowed to settle for 1 hour. The supernatant was collected for analysis and used to find out the dose at minimum turbidity. The dose of coagulant giving the minimum turbidity was considered as the optimum dose.

4.1.2 Filtration

Filtration of wastewater is most commonly used for the removal of residual floc and colloidal matter in settled effluent. Filtration is also used to remove residual precipitates from the metal salt or lime precipitation of phosphate and is used as a pretreatment operation before wastewater is discharged to activated carbon induced applications. The filter column used for treatment is of following specifications.

Depth of sand bed: the depth of sand bed should be between 600-900 mm. For organic matters and bacteria to pass through the filter. Here 1.18-1.7 mm fine sand and 1.7-2.36 mm course sand is used.

Gravel for filter: sand bed is supported on the gravel bed. Gravel bed has several functions it supports the sand and allow the filtered water to move freely to under –drain. It allows wash water to move upward uniformly on sand. The gravel is placed in 4-5 layers having finest at top. Here 2.36 –3.25 mm gravel size is used.

The procedure adopted for the treatment of wastewater filtration is as follows

- Determination of the optimum coagulant dose at optimum PH.
- Apply the optimum coagulant dose to about 5 lit of sample and collect the supernatant.
- Wash the filter column with distilled water and then with the sample.
- Pass the sample and adjust the flow rate 10 ml/min.
- Pass the supernatant collected after coagulation, flocculation through the filter determine MPN and the turbidity of the effluent as well as influent.

Specifications of the Filter column:

Rate of Filtration = 10 ml/min

- Length of base = 955.5 mm
- Length of bed = 500 mm
- Diameter = 48 mm
- Gravel size = 2.36 – 3.25 mm
- Coarse sand size = 1.7 – 2.36 mm
- Fine sand size = 1.18 –1.7 mm
- Area of filtration = 1808 mm2

4.1.3 Ultra-violet rays treatment

Practically in lab, the wastewater directly and after filtration was allowed to flow through the U.V. lamp.G36T5L with a given contact time. This treatment was done to remove all the pathogenic organism and also oxidized some organic matter. The treated wastewater, which was subjected to the radiation, was free from turbidity. Radiation of UV lamp G36T5L (SANKYO DENKI Co. LTD. Made in Japan) provides 30000-micron watts seconds/cm2 of 2537 Angstrom. Wavelength (254 Nanometer) of Ultra violet energy across fluid medium for Silica Quartz Jacket provide 99.9 % efficiency due to its pure crystal clear transparency kill contaminating micro-organism of water.

4.2 SAMPLEING.

TABLE NO 2 : Characterization of sampling done.

Parameters	Sample	Parameters	Sample
PH	9.22	C.H.	420
D.O.	4.7	C.O.D.	115
Temp.	29.3°C	B.O.D.	50

Turbidity	14 NTU	Sulphate	57
Odor	Objectionable	Phosphate	5.2
T.S.	673	Chlorides	89
T.D.S.	652	NH3-N	7.5
S.S.	21	Org. Nitrogen	38.4
T.H.	284	MPN	>1600
		Total Bacterial Count	34500

NOTE: All Values in mg/lit except pH, MPN and Total Bacterial Count
Treatment tried was in following sequence
.Coagulation➔Flocculation ➔ Sedimentation ➔ Filtration ➔U.V.

4.3 Coagulation, Flocculation and Sedimentation Treatment

The treatment of coagulation using alum followed by flocculation and sedimentation and filtration was carried out on the composite sample.The Treatment of coagulation was carried out for Optimum dose and optimum pH ranges to get maximum efficiency for removal of the pollutants in a Jar Test Apparatus.
Optimum Dose.

Table No 3: Treatment results of coagulation, flocculation and sedimentation in Jar Test Apparatus for Optimum dose of Alum

Sr. number	Amount of sample taken	Alum added (mg/lit)	Turbidity (NTU)
0	500	0	10
1	500	10	7.2
2	500	20	6.5
3	500	30	7.5
4	500	40	8.5
5	500	50	10

Optimum dose = 20 mg/lit

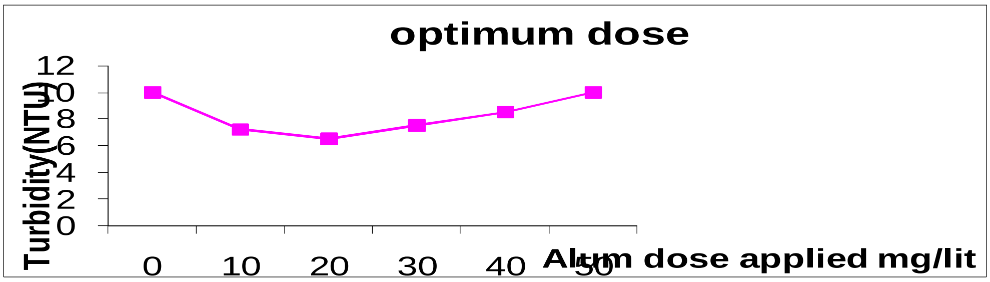

Figure 2: Graphical Representation of the Coagulation Treatment for Optimum Dose determination

Optimum dose at optimum pH

PH is adjusted with 1N HCL and 1N NaOH

Table No 4 : Treatment Results of Coagulation, Flocculation and Sedimentation in Jar Test Apparatus for Optimum pH at Optimum Dose of alum –20 mg/lit.

Sr. number	Amount of sample (ml)	pH	Turbidity (NTU)
0	500	5.57	9.7
1	500	6.57	8.5
2	500	7.57	7.5
3	500	8.57	6
4	500	9.57	6.5
5	500	10.57	7

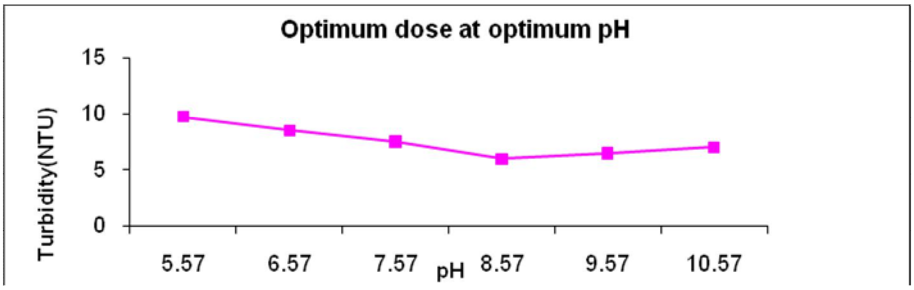

Figure 3: Graphical Representation of Coagulation Treatment at Optimum pH for Optimum Dose

It can be seen from the above that at an optimum dose of 20 mg/lit and at an optimum pH of 8.57 we get maximum efficiency of removal of pollutants, turbidity reduces to 4.5 and SS reduces to 19.17 mg/lit.

4.3.1 Filtration Treatment

After sedimentation the supernatant was collected and was further subjected to filtration for removal of colloidal and suspended particulate fraction. This was carried out in an Filtration Column of the specification as stated above.
The analysis results after filtration was observed as follows:

a. Turbidity = 4.5 NTU d. Temperature = 27.6°C
b. PH = 8.05 e. SS. = 34 mg/lit
c. % Reduction in solids = 56.41 % f. Hardness = 280 mg/lit

Table No 5 : Treatment results of Filtration

Parameters	Before treatment	After treatment	% Reduction
Turbidity	14 NTU	4.5 NTU	67.85 %
SS.	78 mg/lit	34 mg/lit	56.41 %
Hardness	284 mg/lit	280 mg/lit	-

The wastewater still contained the hardness and suspended solids and hence was further subjected to softening treatment (Lime and Soda Process) and treatment of ion exchange for removal of the hardness.

SOFTENING

The treatment of softening was given using hydrated lime and sodium carbonate.
Amount of hydrated lime required = 310.80 mg/lit

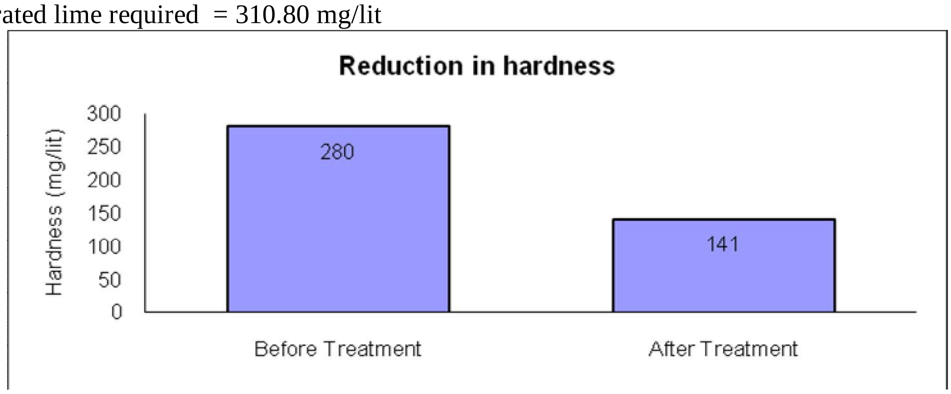

Figure 4 : Graphical Representation of removal of Hardness before and after treatment using Lime Soda Process

4.3.4 ION EXCHANGE

The specifications of the Ion Exchange Column is as below:Cation Exchange Column
Length of column = 48.5 cm
Column regeneration with 3N HNO3
Rate of sample – ml of sample/ml of resin per min = 0.1 – 0.2
Rate of passing the sample = 10 ml/min.
% Reduction in Hardness = 95 %

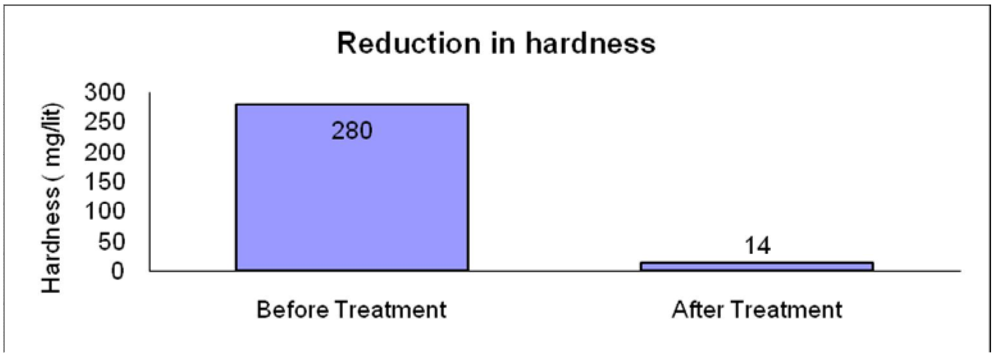

Figure 5: Graphical Representation of hardness before and after treatment of Ion – Exchange Process

4.3.5 Ultra Violet Treatment

Ultra Violet Treatment was tried on the composite sample for removal of the bacteriological contamination after filtration. This treatment was tried batch wise and in continuous flow conditions, giving suitable detention time.
Batch wise treatment :
Sample amount = 2 lit, Contact time = 10 min, After treatment total bacterial count = Nil

Table no 6: Reduction After U.V. Treatment batchwise for second sampling.

Parameter	Before treatment	After treatment
Total Bacterial Count	34500	Nil
MPN	>1600	Nil

Continuous Flow Condition:
At the outlet rate of collecting the sample = 10 ml/min
MPN before treatment – >1600
MPN after treatment –. = Nil
Total Bacterial count before treatment = 34500mg/lit
Total Bacterial count after treatment = Nil
A Table below shown the over all removal in parameters after each stages of treatment carried out on second sampling.

Table No. 7: Table showing the Reduction in parameters after each stage of Treatments carried out for second Sampling

Parameters	Sample	Characteristics after Coagulation, Flocculation and Sedimentation	Characteristics after Filtration	Characteristics after Softening using Ion-Exchange Process	Characteristics of filtered effluent after Ultra Violet Radiations
PH	9.22	8.57	8.5	7.6	7.2
D.O.	4.7	4.2	4.0	3.5	3.0
Temp.	29.3°C	29 °C	29	29	29
Turbidity	14 NTU	6 NTU	2 NTU	2 NTU	2 NTU
Odor	Objectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
T.S.	673	856	870	655	652
T.D.S.	652	846	865	650	647
S.S.	21	10	5	5	5
T.H.	284	280	279	14	280
C.H.	420	415	413	8	414
C.O.D.	115	95	52	35	50
B.O.D.	50	42	24	12	15
Sulphate	57	68	72	71	75
Phosphate	5.2	4.2	4.2	3.9	4.0
Chlorides	89	124	134	130	135
NH3-N	7.5	7.0	7.0	6.9	7.0

Org. Nitrogen	38.4	35	35	34	30
MPN	>1600	>1600	>1600	>1600	Nil
Total Bacterial Count	34500	34500	34500	34500	Nil

NOTE: All Values in mg/lit except pH, MPN and Total Bacterial Count

5. DESIGN OF TREATMENT PLNAT FOR REUSE

Table 8: Design of units of treatment plant

1	Collection sump (R.C.C.)	10 x 10 x 4.0 400 m3 '@ 1.8 / litre
2	Primary effluent pump	25 m3/hr 10 m head(5 HP)
3	Flash mixer tank	1.5m x 1.5m x 2.3m 5.175 m3 @ 4/ litre
4	Flocculator tank	(3.6m x 1.8m x 2.3m depth)14.904 m3 '@1.8 Rs./lit
5	Clarifier	8.0 m dia. x 2.8 m depth = 140.672 m3 '@ 3.0 Rs./litre
6	Flash mixer agitator M.S.structure	suitable for tank size 1.5m x 1.5m x 2.3m 2 HP
7	Flocculater mechanism M.S.structure	suitable for tank size 1.5m x 1.5m x 2.3m 2 HP 1.5 HP each
8	Intermediate collection tank	(4.5 x 4.5 x 2.8)m 56.7 m3@ Rs.2.5/lit
9	Filter Feed pumps	30 m3/hr ,40 m head,7.5 HP
10	Pressure sand filter	capacity 25m3/hr
11	Activated carbon filter	capacity 25m3/hr
12	Final collection sump	(10 x 10 x 4)m-400m3 '@1.8/lit
13	Clarifier mechanism M.S. structure suitable for tank	8.0 m dia.x 2.8 m depth - 140.762 cu.m '@1.8 Rs / litre
14	Ultra violet Radiation modules - 4 Nos.- 10 m3/hr each	40 m3/hr
15	Softner system	10 m3/hr capacity
16	Softner feed pump	15 m3/hr 20 m head 3HP

6. RESULTS OF DOMESTIC WASTE WATER TREATMENT

For the present study, the analysis of treated effluent from the Atladra New sewage Treatment Plant was carried out and studying the results, the various treatments were given in the laboratory with reference to the reuse possibilities for the industries on the down stream of the plant.

- If the treated effluent is treated by coagulation and sedimentation using alum 20 mg/lit of optimum dose and 30 min. detention time, the turbidity remains less than the permissible limit and as the P^H of the treated effluent gives the optimum results, here P^H adjustment is not required.
- The treated effluent from clarifier when treated on laboratory scale by preparing a filter column having,
  Diameter = 4.8 cm, Gravel size = 2.36 – 3.25 mm, Coarse sand size = 1.7 – 2.36 mm
  Fine sand size = 1.18 –1.7 mm
  With a flow rate of 10 ml/minute, C.O.D. and solids of the effluent are reduced to a max. Limit. The actual field study with more control devices may give some better results than this. This type of treated effluent can very well be used for industrial purpose.
- If this treated effluent after filtration is required to be reused for boiler feed purpose where hardness required is < 50 mg/lit, then ion exchange treatment gives the hardness below 20 mg/lit which is fit for boiler feed purpose. The hardness removal by lime treatment also reduces the hardness by about 50 %.
- The treated effluent was given the disinfection treatment by passing from UV lamp in the laboratory by the bacth wise and continuous condition for 10 min and 12 min duration, at a rate of 10 ml/min at the outlet. The treated effluent was having MPN <2 and total bacterial count nil. This shows that UV treatment is more effective for disinfection. But for more quantity the method may not be economical.

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