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EVALUATION OF FUNCTIONING OF WASTE WATER TREATMENT PLANT AT CHANDRAWATI EDUCATION SOCIETY, JAIPUR: A CASE STUDY

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ABSTRACT

The rapid growth of population led the technological and industrial advancement which has brought enormous problem of pollution and deterioration of all the segment of environment. The pollution of water and its scarcity made necessary for treatment of industrial &domestic waste water.The study area selected is sewage treatment plant at CES, Jaipur, for its evaluation &functioning .The STP uses Fluidized Aerobic Bed process for secondary treatment .The untreated waste water &treated water was analyzed for Ph, EC, TDS, TSS, BOD, COD, Cl^- $N0^{3-}$ PO^{4-} as per APHA manual. The results of above analysis were found very high for waste water, but for treated water it was found with in the limit .Treated water can be used for gardening and irrigation purpose without any harm to flora &fauna of the region. Last eight months physical observation of FLORA and FAUNA of the region showed no apparent damage on the morphology ,physiology ,growth and distribution on them and , the result of soil analysis also confirms no extra harmful contents increased after using treated water .It has improved present and future water supply, demand . It has been estimated that almost 80% of waste water is recovered by establishing waste water treatment plant and the treated Water can also be used for toilet purpose.

Keywords: STP, FOG, FAB, BOD, COD, TSS Etc

INTRODUCTION

Water is undoubtedly the most precious and invaluable natural resource that exists and covers 70% of the Earth's surface, on our planet. It is essential for everything to grow and prosper in our planet. Although, we human beings recognize this fact but we disregard it by polluting our rivers, lakes and oceans. Subsequently, we are slowly but surely harming our planet to the point where organisms are dying at a very alarming rate. In addition to innocent organisms dying off, our drinking water has become greatly affected as is our ability to use water for recreational purposes. In order to combat water pollution, we must understand the problem and become a part of the solution [1].

The purification of waste water of various industrial processes is a world wide problem of increasing importance due to the restricted amounts of water suitable for direct use, the high price of the purification and the necessity of utilizing the waste products. The diverse spectrum of wastes water requiring efficient treatment has focused the attention of researchers on membrane treatment, ion-exchange and biological technologies. The most effective and ecological technological system developed during the past 20 years are as on a combination of the chemical, physical and biological methods. The present investigation is aimed to water quality analysis of waste water and suitability of this treated water for irrigation purposes /gardening and for uses in toilets [2].

MATERIAL

Site Description

Rajasthan is known as a land of Kings & Queens. It is very famous all over the world for art, artifacts, color, culture, cuisine &tradition. The Jaipur is fastest developing city of Rajasthan with relatively less pollution and is a growing educational hub. Jaipur is well connected by rail road and air from rest of Indian Cities .RAJASTHAN COLLEGE OF ENGINEERING FOR WOMEN ,JAIPUR(RCEW) and RAJASTHAN INSTITUTE OF ENGINEERING AND TECHNOLOGY(RIET), a unit of Chandrawati Education Society(CES) is situated at AJMER ROAD at 75^0 east longitude and 26^0 north latitude . College is situated in a sprawling campus of about 12acres about 10KM away from city centre. There are two colleges in this premises that is RIET (2000) &RCEW (2002) total strength of students is 5000 in which 1500 are staying in the hostel situated in the campus. Soil is normal sandy soil. The place was earlier used for agricultural purpose. Entire campus is very clean &green, well lay out play grounds and walking pathway .The lawns are maintained properly and almost 500 green trees are planted all around the campus. To maintained this lush green environment, large amount of water was required which was difficult to get as institutions used to face acute water scarcity in summer month as well as disposal of sewerage water was great problem [3].

Population Growth

The principle factor for determine the future water needs of RCEW & RIET and utilization of waste water for gardening and toilet purpose is dynamic& exponential growth of both the institute in infrastructure and number of the students, because environment of college was student friendly as well as strict discipline in college and hostel have attracted parents and provided them sense of safety &well being of their wards. As these factors had increased the capacity of students in hostel so the need & use of water has increased, simultaneously the disposal of waste water has increased manifold. At present the strength of students in RCEW & RIET us almost 5000.

Present Water Supply Status

The present water supply in RCEW and RIET is 125000 litres per day. In RCEW requirement is 78000 litres/day and RIET 51000 litres/day. This supply is met by boring pump situated in the campus (7.5 HP x 4). At north &East direction, almost 200 metres away from each other. The per student usage of water per day is 100 litres.

Drainage System Detail

RECW and RIET drainage scheme has been designed to collect bath room / kitchen water .The water coming out from these two areas are rich in washing powder ,oil detergents but dose not contains urine or faecal matter hence it does not give foul smell and is called non foul waste water. However the water which comes out from lavatories and toilets contains biodegradable faecal matter and is called foul waste water. Both types of water are transported in college through underground pipes made of china clay or some places plastic Pipes .These are then led into the main drain of the college from where through inspection chamber it is led into various wells. There are total 4 well in the campus. Well no-1 collect water form RCEW admin building, hostel & hostel mess. The well no II collect water form academic building II and III through last inspection chamber, laid under the walking pathways. For regular inspection and cleaning of the sewer line man holes are provided at every change in diameter /change in alignment / steep, from these drains water goes into the Main well.

The well no 3 collect water from RIET girls hostel & Academic building. The well no 5 collect water form admin building RIET and part of boys hostel. The well no 6 collect water from new boys hostel of capacity 600. All the well water then meets on the collection tank which is having the capacity of 1 lakh liters. The entire networks of sewage collecting systems, sub pumping stations and a sewage treatment plant constitute the sewage treatment plant [4, 5].

Description of Sewage Treatment Plant (STP)

It includes four steps:

Fig 1, Sewage Treatment Plant At Ces, Jaipur

Pretreatment or Preliminary Treatment

It involves removal of large object like stones, sticks, leaves, as well as gravels, sand, silt (called gritty substances), fats, oils, greases (called FOG) which if not removed can damage pumps, equipments and greatly add to loading on the normal treatment process. It is done by Screening &Pre sedimentation in this water is allowed to be collected in an underground sedimentation tank by passing through a large screens placed slanting at the inlet of the water. This leads to removal of 30-40% of suspended matter (Centre for Water Resources [6].

Primary Treatment

It removes the major portion of waste present in the water. It consists of physical process of removing solids by process of settling. The settled solids are conveniently removed as sludge. For this the waste water is passed through big tanks called primary sedimentation tanks. In this the faecal solids and colloidal impurity are allowed to settle down. Retention time is typically 3 hrs. In tanks of 10 to 15 feet deep. This process is capable of removing 80- 90 % of satiable solids solid and 65% of suspended solids and up to 45% of Biological oxygen demand (BOD) substances. The main purpose of primary treatment is to produce a homogenous liquid capable of being treated biologically and a sludge that can be separately treated or processed [7.]

Secondary or Biological Treatment

The main objective of this treatment is to degrade the biological contents of sewage such as derived form human waste, food waste and detergent. The secondary treatment is required to lower the BOD is conceptually similar to the process of decomposition taking place in nature.

In this method organic wastes are degraded by microbial in the waste treatment tanks. Presence of adequate microbial population and supply of oxygen is maintained for the effective operation this process [8].

Fluidized Aerobic Bed Process (FAB)

This process consists of a suspended growth system in which a mass culture of micro-organisms supported on media comes in contact with waste water in the aeration tank having 4-5' height and 6 feet diameter .To ensure effective treatment process two aeration tank are taken. Waste water after primary treatment enters the aeration tank know as reactor in which a fluid or liquid is passed through a large no of plastic circular media having void around the surface at high enough velocities to suspend the solid and cause it to behave as though it were a fluid. The fluid is then forced through the distributor up through the solid material. At lower fluid velocities, the solids remain in place as the fluid passes through the voids in the material. This is known as a packed bed reactor. As the fluid velocity is increased, the reactor will reach a stage where the force of the fluid on the solids is enough to balance the weight of the solid material. This stage is known as incipient fluidization and occurs at this minimum fluidization velocity. Once this minimum velocity is surpassed, the contents of the reactor bed begin to expand and swirl around much like an agitated tank or boiling pot of water [9].

Air is introduced into the tank to provide the oxygen necessary for the survival of micro-organisms in the form of bubbles through diffusers or by surface aeration. The micro-organisms utilize the oxygen in the air and convert the organic matter into stabilized, low energy compounds such as sulphate and carbonates. Evolution of carbon dioxide and growth of microbial mass also takes place. Following are advantages of FAB Process.1.Uniform particle mixing2.Uniform temperature gradient3.Ability to operate reactor in continuous state [10, 11].

Settling chamber

It consist of square setting chamber which at the bottom is conical at angle of 45^{0} to collected the sludge ,inside this chamber is divided by polymer slanting plate which help in slowing down the speed of water as well as increase the surface area and help in settling the sludge by gravitational force. Almost $1m^2$ surface filters 1500 litre of water /hr .the water from here passed to next step[12].

Tertiary Treatment or Advanced Treatment

It is used to produce water of high quality. Tertiary treatment is the most advanced phase of sewage treatment which is provided to only 2% of domestic sewage. The main function of tertiary treatment is to remove the load of nitrogen and phosphorus compounds in the effluents. It also aims at removing toxic substances and disinfecting water.It is being achieved in a number of ways: 1.Sand filter2. Carbon filte3. Disinfection [13].

METHODOLOGY

To assess the functioning of STP, the waste water quality has been studied by collecting water samples by grab sampling method from all the wells during pre flowing and post flowing stages in plastic containers previously cleaned by washing in detergent, rinsed with tap water and later soaked in 10% HNO_3 and finally rinsed with deionised water prior to usage. During sampling, sample bottles were rinsed with sample water and sample were stored at 4^{0} c temperature, to avoid any change in its characteristics. Samples of untreated water mixture were collected from under ground storage tank of capacity of 100000 liters. Then samples of treated water were collected at primary treatment, secondary treatment

stages at morning and evening. These were analyzed for Ph, EC, TDS, TSS, BOD, COD, Cl^- $N0^{3-}$ PO^{4-} [14].

Table 1: Equipment list used in the analysis process

S.N	*Equipment*	*Modal*	*Manufacturer*
1	pH- meter	pH 213	Hanna
2	Conductivity meter	Cc 601	Century
3	UV-VIS Spectrophotometer	1800 ENG 240V	Shimadzu
4	Digital Balance (4 digit accuracy)	AB204-S	Mettler Toledo
5	Atomic Absorption Spectrophotometer	AA-7000	Shimadzu

Analysis of Physiochemical Parameters

The chemicals used were of AR grade. Double distilled water is used for the preparation of solutions and reagents. Following parameters were analyzed according to APHA manual [7]for the examination of waste water. pH and electrical conductivity were carried out by using pH-meter and conductivity meter respectively. Total dissolved solid(TDS) and Total suspended solid(TSS)were determined by "filtration methods". Chemical oxygen demand (COD) was determined by the dichromate reflux method while Biological oxygen demand (BOD) was determined by the dilution method. Nitrate ion and Phosphate ion were determined by using Atomic Absorption Spectrophotometer (AAS)[15].

All equipment (table-1) were checked and calibrated according to the manufacturer's specifications. The pH meter was calibrated using buffers of pH 4.0 and 7.0; conductivity meter was calibrated by using conductivity water. The spectrophotometers were checked for malfunctioning by passing standard solutions of phosphates and nitrates to be measured; Blank samples (deionized water) were passed between every four measurements of effluent samples so as to check for any eventual contamination or abnormal response of equipment [16].

RESULT AND DISCUSSION

Characterization of the physicochemical parameters of Waste water samples from main collection tank inCES, Jaipur Rajasthan and is reported in (Table -2). The experiment results are compared with standard data as per WHO and Indian council as medical research (ICMR) and Bureau of Indian Standard (BIS) considerably deviations are observed in the Quality of Waste water effulent limit parameters from the standard limit. The results of physico-chemical parameters of treated water samples after primary and secondary treatment are reported in table 3, 4. The results are a compliance of Environmental regulations[17].

Temperature

The temperature of waste water was determined at the site and it was within the limit (>50) in all the samples because the collected water is of domestic use.

Ph

It tells about acidity and alkalinity of waster water it was determined by using digital ph meter using combined glass electrode at the site.The tolerances limit for sewage effluent discharged into surface water sources is 5.5-9.0. All the collected samples were of various alkalinity levels (8.0-12.0).

Electrical Conductivity

It gives an idea about the dissolved solids in water. Greater the amount of dissolved solids higher will be the conductivity... It is measured easily with the help of digital conductivity meter as per the instructional manual. the conductivity of all the samples were very high before the treatment as per table 2 but after the primary treatment the conductivity decrease(table 3)but sharp decrease was found in the samples after the treatment as per table 3.

Total Dissolved Solid

It is measured by evaporating a sample to dryness in a pre-weighed dish first in a water-bath and then dried in a oven to a constant weight at 180 ^{0c}and then cooling &weighing the residue .Total tolerance limit for TDS discharged into sewer line is 2100mg/l.The variation of TDS for waste water before and after the treatment is shown as per fig-1.There is sharp decrease (60-70%) in TDS after the treatment because of oxidative degradation of dissolved waste solid.

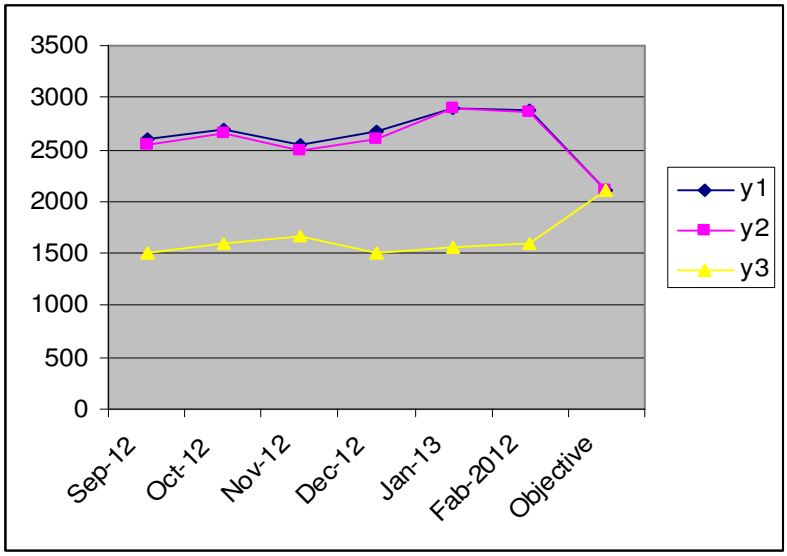

Fig. 1 variation of TDS before and after treatment, y1 before treatment, y2 after primary treatment, y3 after FAB treatment

Total Suspended Solid

Filtration method is used TSS determination, a well mixed sample is filtered through a pre-weighted standard glass fibre filter and the residue is retained on the filter.It is dried to a constant weight at 103-105$^{0c.}$ The increase in weight of the filter represents the total suspended solids. It should not be more than 100 mg/l.The variation in TSS before and after treatment is as per fig. 2 the sharp decreases (73%) in TSS after the primary treatment is attributed for keeping waste water t undisturbed for 8-9 hrs in the sedimentation tank.

Chloride

The presence of chloride in waste water indicate the salt deposition. The argen -to-metric titration method is used for estimation of chloride. Its amount in waste water should not be more than 500 mg/l, high percentage of chloride in water harms metallic pipe and agricultural crops. The cl^- conc in waste water was not very high because it does not contain industrial waste water, slight excess was removed by FAB method.

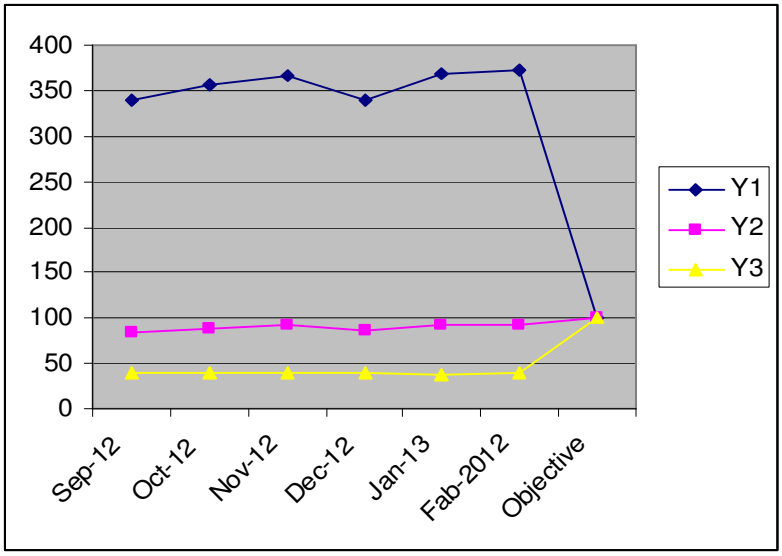

Fig. 2, variation of TSS before and after treatment, y1 before treatment, y2 after primary treatment, y3 after FAB treatment

Nitrates

In waste water, main source of nitrate is chemical fertilizer, decayed vegetable& animal matter, domestic effluents, sewage sludge and industrial effluents .It is determined by U.V spectrophotometer .its limit in waste water should not be more than 50 mg/l.The variation of $N0^{3-}$ before and after the treatment is as per fig 3.There is almost 86% decrease in nitrate value after the FAB treatment because of oxidative degradation of Nitrate in this process.

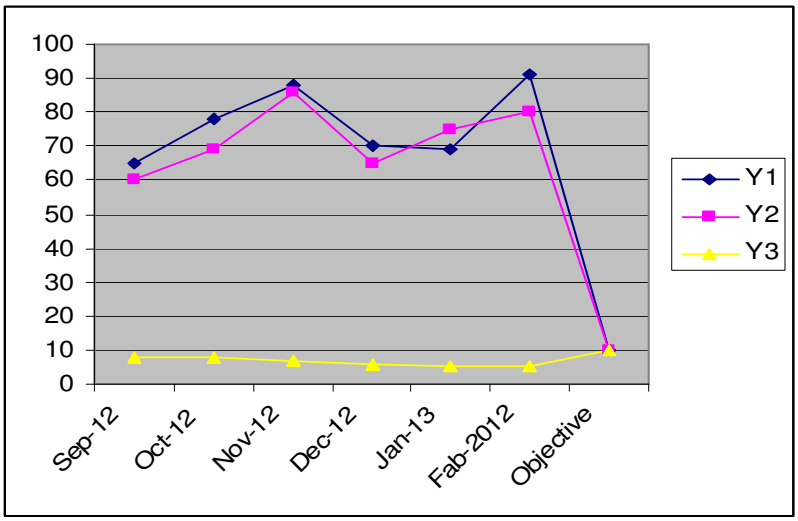

Fig. 3, variation of NO^{3-} before and after treatment ,y1 before treatment ,y2 after primary treatment,y3 after FAB treatment

Oil and Grease

In the waste water oil and grease comes from kitchen waste and use of soap and detergent.The oil and grease was determined by using solvent extraction method and recovering it through distillation process. Its limit in waste water should be not more than 10 mg/l because if present in excess it may interfere with aerobic anaerobic biological processes

and led to decreased waste water treatment efficiency. The fig,4 explain its variation in waste water before and after treatment .The FAB process removes almost 90% oil &grease [18].

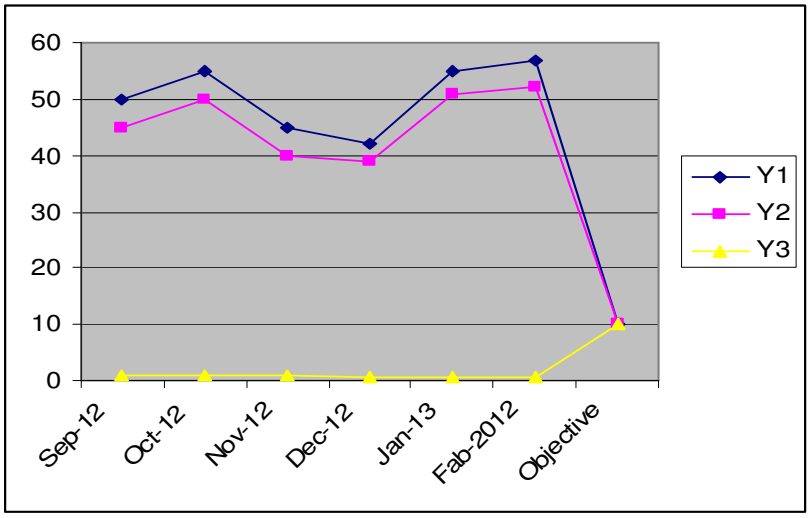

Fig. 4, variation of Oil &Grease before and after treatment, y1 before treatment, y2 after primary treatment, y3 after FAB treatment

Phosphate

In waste water phosphate comes from sewage and industrial effluents. It is determines by U.V. spectrophotometer. Its limit should not be more than 10 mg/l. There is sharp decline (60%) in phosphate level in waste water after the treatment because of effective FAB technology.

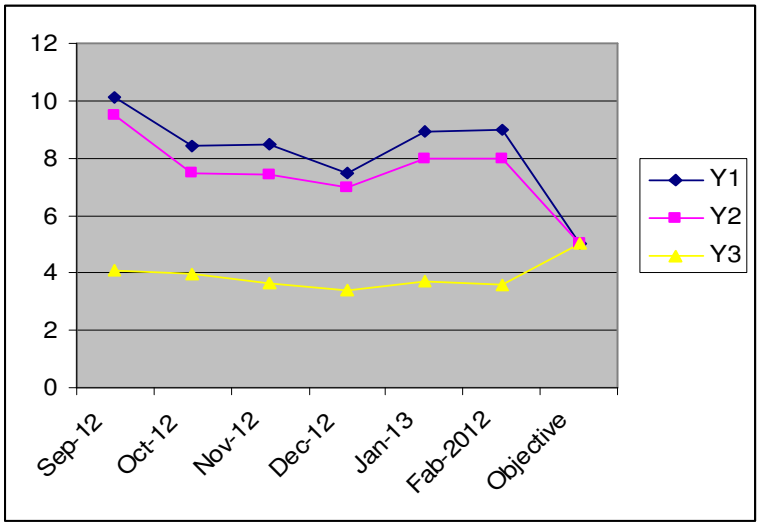

Fig. 5 variation of PO^{4-} before and after treatment, y1 before treatment, y2 after primary treatment, y3 after FAB treatment

Bod

BOD is a measurement of the amount of oxygen required by microorganism to cause the breakdown of organic matter and the oxygen used to oxidize inorganic material such as sulphide and ferrous iron. Iodometric titration method is used for its determination. Its limit in waste water should not be more than 50 mg /l. high BOD in water indicate high amount of

organic matter. The variation of BOD value is as per grap no-6 before and after the treatment the 94% removal of BOD is attributed for the micro-organisms utilizing the oxygen in the air and converting the organic matter into stabilized, low energy compounds such as sulphate and carbonates. Evolution of carbon dioxide and growth of microbial mass also takes place.

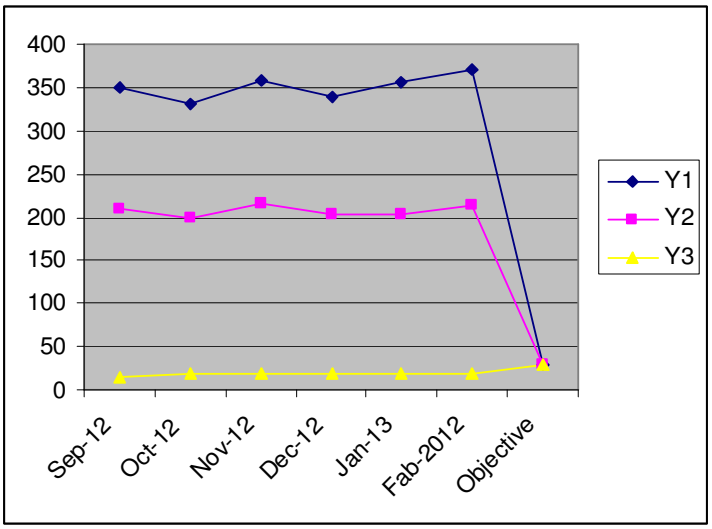

Fig. 6 variation of BOD before and after treatment, y1 before treatment, y2 after primary treatment, y3 after FAB treatment

Cod

Open reflux titrimetric method is used for its determination, its limit in waste water should not be more than 100mg/l. The 80% removal of COD is attributed to uniform mixing, uniform temperature gradient and effective microbial decomposition[19].

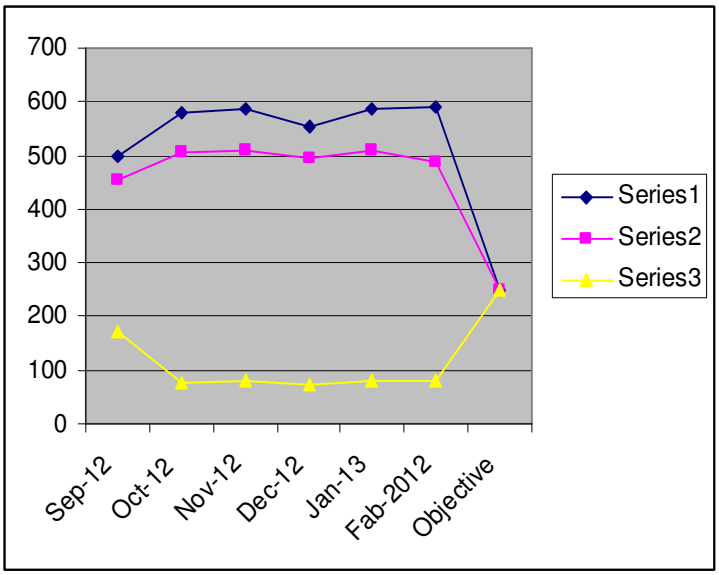

Fig. 7 variation of COD before and after treatment, y1 before treatment, y2 after primary treatment, y3 after FAB treatment

Table 2: Physico-chemical parameter of Waste Water effluent at CES , Jaipur, Rajasthan,2012

Parameter	*Sept-2012*	*October-2012*	*Nov-2012*	*Dec-2012*	*Jan-2013*	*Fab-2012*	*Objective*
Temp	22-24	22-30	20-21	19-20	19-20	20-21	Should not $>50^{0c}$
PH	8.4-11.9	8.0-12.0	8.3-11	8.5-12	8.4-11.5	8.3-11.2	5.5-9.0
EC	3.7-6.7	2.9-4.1	2.7-3.34	2.6-3.5	3.7-4.0	3.9-4.2	1.0
TDS	2600	2700	2550	2670	2900	2875	2100
TSS	339	356	367	340	369	372	100
BOD	350	330	358	339	356	370	30
COD	500	578	585	555	586	589	250
Oil & Greese	50	55	45	42	55	57	10
CL^-	1200	1100	1187	1187	1190	1196	1000
NO^{3-}	65	78	88	70	69	91	10
PO4-	10.1	8.4	8.5	7.5	8.9	9.0	5.0

Temp-0c,Ec-s/cm,All others-mg/l

Table 3: Physico-Chemical parameter of Waste Water After Primary Treatment at CES , Jaipur, Rajasthan,2012

Parameter	*Sept-12*	*Octo-12*	*Nov-12*	*Dec-12*	*Jan-13*	*Feb-13*	*Objective*
Temp	21-22	20-22	19-20	19-20	18-20	19-20	Should not $>50^{0c}$
PH	9.5	9.0	9.65	10.25	9.9	9.5	5.5-9.0
EC	4.5	3.5	3.02	3.05	3.85	4.05	1.0
TDS	2550	2650	2500	2600	2900	2865	2100
TSS	84.73	89	91.1	85	92.25	93.0	100
BOD	210	198	214.8	203.4	203	213	30
COD	456	505	509	495	510	486	250
Oil &&grease &Greese	45	50	40	39	51	52	10
CL^-	1150	1050	1150	1100	1150	1146	1000
NO^{3-}	60	69	86	65	75	80	10
PO4-	9.5	7.5	7.4	7.0	8.0	8.0	5.0

Temp-0c,Ec-s/cm,All others-mg/l

Table 4: Physico-Chemical parameter of Treated Waste Water effluent at CES, Jaipur, Rajasthan,2012

Parameter	*Sept-2012*	*Octo-12*	*Nov-12*	*Dec-12*	*Jan-13*	*Fab-13*	*Objective*
Temp	21-22	20-22	19-20	18-20	19-20	19-20	Should not $>50^{0c}$
PH	7.69	7.77	8.1	7.9	8.0	8.5	5.5-9.0
EC	1.13	1.0	.987	.987	.99	.90	1.0
TDS	1500	1600	1668	1501	1559	1602	2100
TSS	39.84	38.93	39.99	38.99	38.01	40.1	100
BOD	14.74	17.9	18.97	18.00	19.1	19.2	30
COD	171.46	76.7	79.1	73.1	79.2	79.9	250
Oil &Greese	.847	.875	.987	.756	.678	.567	10
CL^-	987	877	988	880	895	798	1000
NO^{3-}	8.0	7.9	6.89	6.00	5.09	5.00	10
PO4-	4.1	3.97	3.66	3.38	3.7	3.6	5.0

Temp-0c,Ec-s/cm,All others-mg/l

Table 5: Physico-Chemical parameter of top soil analysis before and after using treated water at CES,Jaipur, Rajasthan,2012

Parameter	*Before treatment*	*After treatment*	*Objective*
PH	8.6	8.9	6.5-7.5
EC	0.10	0.46	<2
Carbon	0.17	0.20	>2
phosphate	21	18	-
potassium	255	218	-

Ec-s/cm,All others-mg/l

CONCLUSION

The present investigation is aimed at Waste Water quality analysis &the suitability of this treated water for irrigation purposes /gardening and for uses in toilets. This study highlights the use of treatment plant improves Quality of Waste Water. These were analyzed for Ph, EC, TDS,TSS,BOD, COD, Cl^- $N0^{3-}$,$P0^{4-}$. The experiment results are compared with standard data as per WHO and Indian council as medical research (ICMR) and Bureau of Indian Standard (BIS).The results of untreated waste water was found very high but treated water was found with in the limit. It can be used for gardening and irrigation purpose without any harm to flora &fauna of the region . Last eight months physical observation of FLORA and FAUNA of the region showed that their growth and development was normal and no apparent damage on them was observed.The result of soil analysis(table no-5)also confirms , no extra harmful

contents increased after using treated water for gardening and irrigation purpose .It has improved present and future water supply, demand . It has been estimated that almost 80% of waste water is recovered by establishing waste water treatment plant and the treated Water can also be used for toilet purpose by laying down separate pipeline .So,the present investigation confirms & definitely improves the water management aspects at RCEW, Jaipur, Rajasthan.

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