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Evaluation of an Effluent Treatment Plant – A Case Study

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Abstract: ***Regular monthly monitoring of effluent quality from a treatment plant at Mahindra & Mahindra tractor assembly plant in MIDC area, Hingna, Nagpur from 2009 to date indicated over 90 per cent removal of relevant effluent quality parameters for an automobile assembly plant viz. BOD,COD, oil & grease, suspended solids etc. ETP has been designed to treat waste water @ 300m^3/day by activated sludge extended aeration system presently treating about 170 to 190 m^3/day. MLSS are being maintained at 3000 ± 500 mg/L and MLVSS are 1400±200 mg/L. F/M ratio is 0.21 for present flow. Variation in influent quality in terms of COD, BOD, O & G and suspended solid values was respectively 650 to 1875, 118 to 356, 69 to 180 & 124 to 375 mg/L. Treated effluent COD and suspended solids were less than 30 mg/L and O & G was absent. Average ionic load in treated effluent is 11.1 m eq/L and organic load being negligible was could to tertiary treatment by R.O process and permeate is being used in manufacturing process thereby saving @ 170 to 190 m^3/day.***

I. INTRODUCTION

A tractor assembly plant of M/s Mahindra & Mahindra is located within MIDC industrial area near Nagpur. This unit was commissioned about 47 years ago. MIDC provides water supply to all units in the area. There is no sewerage system for this industrial area. All units in the area had to install their effluent treatment plants in their respective premises as per State Pollution Control Board consent to operate industrial unit. Plant receives most parts including subassemblies from supplier units and assembles them in to "brand tractor". Major operations are a) transmission machining assembling & testing, b) engine machining, c) hydraulics machining, d) tractor sub assembly, chassis painting, final assembly, e) testing and f) sheet metal painting. These operations need welding, phosphatizing along with cleaning, rinsing, phosphatizing etc. During painting a primer coat of paint is electrostatically deposited on metal surfaces. Electrically charged metal is dipped in to tank of water –based paint. Paint particles which are oppositely charged deposit evenly to the surface. Demineralized (DM) water is used for make-up. Paint tank gets heated and is cooled to less than 30°C in an open re-circulating cooling tower. Then the tractor is dried/baked in a dryer to ensure finish. There are heat exchangers for heat- recovery. Concentrated rinse water from 'electrostatic coating unit' is released in to effluent treatment plant. Other miscellaneous uses of water are a) assembled tractor is passed through a spray using fluorescent dye and b) a final tractor wash.M & M is "environment conscious" and has voluntarily conducted i) water audit, ii) feasibility of rain water harvesting, iii) tertiary treatment of sewage treatment plant effluent etc. ETP has been designed to treat wastewater @ 300 m^3/day. Water audit enabled optimization of water use. It included performance evaluation of its effluent treatment plant (ETP) and the sewage treatment plant. Water audit and ETP evaluation was entrusted to Enviro Techno Consult (ETC), now ETCPL has been recognized as In-house R&D Unit by Department of Scientific and Industrial Research (DSIR), Department of Science and Technology (DST), Govt. of India, New Delhi. Findings of these surveys and the initiative by the plant authorities led to tertiary treatment of ETP and STP effluents, then recycle and reuse treated wastewater in manufacturing processes. Thus fresh water consumption was reduced.

Improved water management practice at the plant has reduced wastewater generation to about 190 -200 m^3/day.

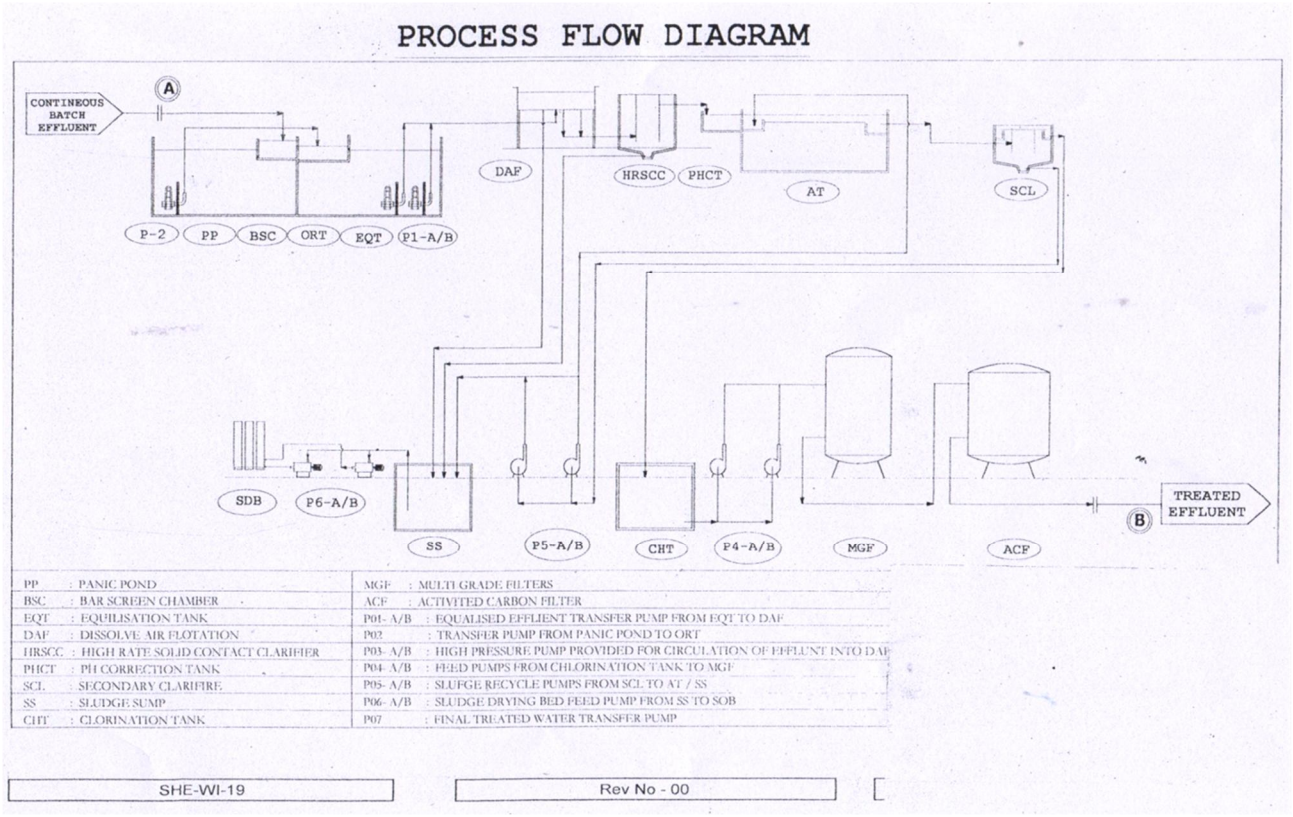
II. PURPOSE OF PAPER

This paper includes findings of performance evaluation of ETP which treats process wastewater. ETP inlet and outlet characteristics since 2009 to date have been summarized and were used for tertiary plant/ R.O. design. ETP flow sheet is included in **Figure1**.

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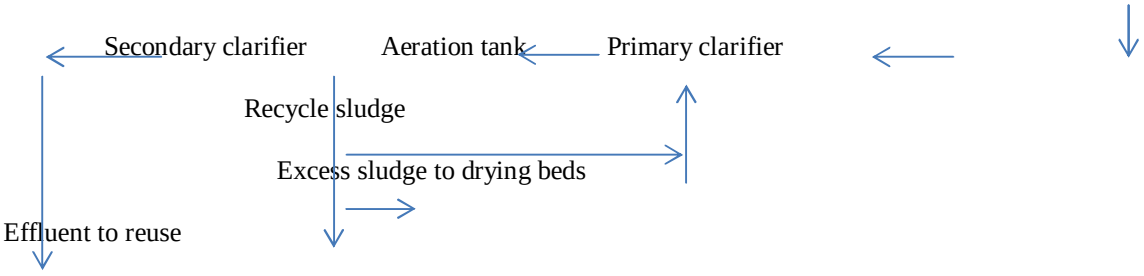
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Figure 1.



Flow sheet

Screen →O&G tank-→ Equalization → Diffused air floatation →



Present wastewater treatment scheme has been designed to treat pollutants in untreated wastewater which are dissolved and suspended solids, oil & grease, BOD, COD, phosphates etc. Process wastewater from all sections enters a panic pond. Then it passes through bar screens after which waste enters a O & G trap. It is treated chemically for demulsifying oil & grease and skim oil. Skimmed oil is stored separately for its disposal to common hazardous waste treatment facility as per pollution control directions. Wastewater is equalized in a separate tank and enters a conventional extended aeration activated sludge system. MLSS are maintained at 3000 ± 500 mg/L and MLVSS are 1400±200 mg/L. Biologically treated waste enters a secondary clarifier. Part of settled sludge is recycled to aeration tank to maintain MLSS. Excess sludge is transferred to sludge drying beds. Sun –dried sludge is used for soil conditioning in gardens. ETP treats wastewater @ about 170 ±20 $m^{3/}$d. ETP Tank capacities are i) bar screen 1.6 m^3,ii) O & G tank 6.5 m^3,iii) equalization tank &iv) diffused air floatation tank 150 m^3each, v) aeration tank 170 m^3 and vi)secondary settling tank 42 m^3. Detention times for maximum flow @190 m^{3+}/d in these tanks would be 10 min. in bar screens, in O & G tank-50 min, equalization & diffused air floatation tank -19 hours each , aeration tank – 21 hours and would be 5 hours in secondary settling tank . ETP inlet and outlet quality is being monitored daily for pH and settling characteristics of mixed liquor suspended solids. Composite samples of inlet and outlet of ETP are being collected randomly once in a month since 2009 and are analyzed for pH, O&G, total, dissolved and suspended solids, BOD, COD, chlorides, alkalinity etc. Analyses are being carried as

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per Standard Methods for Examination of Water & Wastewater AWWA, APHAi, Her Majesty's publication entitled Water and Waste Water Manual and NEERI publication "Water analysis & wastewater treatment [iii] .

III. RESULTS

Yearly averages of pollutants in wastewater since 2009 till October 2017 were calculated and standard deviations for these except pH were calculated. Year wise untreated wastewater quality entering the ETP since 2009 is given in Table 1.

Table 1: ETP inlet quality

Parameter	2009	2010	2011	2012	2013	2014	2015	2016	2017
pH	6.5-5.4	7.0-8.8	7.0-8.6	6.6-8.1	6.2-7.4	6.8-7.5	6.6-7.9	6.9-9.3	6.2-9.0
TS	2690	2645	2415	2231	1494	1581	2581	2013	1870
TDS	2348 ±329	2270 ±394	2094 ±1256	2012 ±522	1293 ±511	1357 ±276	2386 ±400	1888 ±503	1746 ±287
TSS	342 ±60	375 ±127	321 ±219	219 ±68	201 ±16	224 ±49	195 ±60	125 ±41	124 ±29
COD	650 ± 268	974 ± 426	1704 ±1756	1535 ±618	1139 ±372	536 ±228	1308 ± 625	1238 ± 493	1875 ±625
BOD	118 ± 57	255 ± 195	343 ± 355	337 ± 103	271 ± 99	114 ± 43	356 ±201	275 ± 97	349 ± 44
O&G	140 ±18	160 ±20	70 ± 66	157 ±72	142 ±27	69 ±32	128 ±44	150 ±24	148 ±27
Chloride	140 ±94	160 ±537	70 ±340	157 ±88	142 ±65	69 ±42	128 ±45	150 ±157	148 ±52
Sulphate	54 ±33	50 ±13	31 ±28	42 ±26	28 ±14	32 ±13	35 ±25	34 ±36	31 ±20
Phosphate	7±2	21±23	9±12	10±3	7±3	2±2	7±5	1±1	1±1
BOD/COD	1:6	1:4	1: 5	1:5	1:4	1:5	1:4	1:5	1:5

N.B. All Values except pH are in mg/L and rounded to nearest decimal

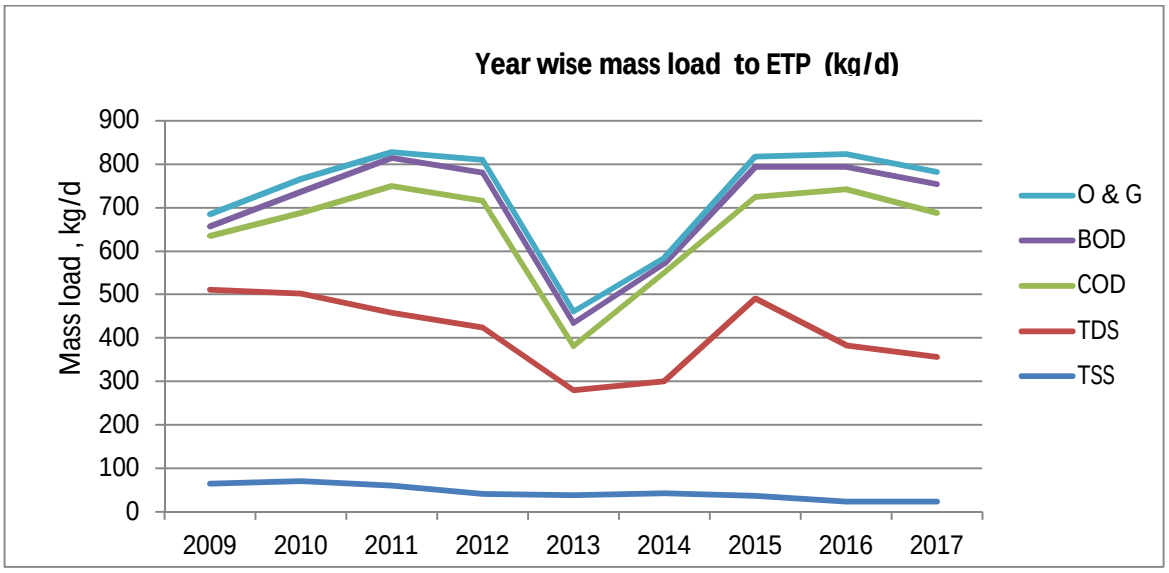
Mass load entering the ETP was calculated. Pollution-mass load of TSS, TDS, BOD/COD and O&G is given in **Table 2** and plotted in Figure2. Variations in pollution load can be due to variation in production pattern.

Table 2: Year wise inlet mass load to ETP (kg/d)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	Mean
TSS	65	71	61	42	38	43	37	24	24	45
TDS	446	431	397	382	242	258	453	359	332	367
COD	124	185	291	292	102	249	235	359	332	241
BOD	22	49	65	64	52	22	68	52	66	51
O&G	27	30	13	30	27	13	24	29	28	25

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Figure 2



Yearly averages of treated effluent quality are given in Table 3.

Table 3: Treated effluent quality

Parameter	2009	2010	2011	2012	2013	2014	2015	2016	2017
pH	7.1-8.1	6.4-8.4	7.0-7.8	7.2-7.6	6.8-7.5	6.3-7.4	7.0-8.0	6.1-7.9	7.2-8.2
TS	985	1124	1126	1351	992	787	140	825	817
TDS	967 ±77	1105 ±371	1105 ±350	1334 ±361	973 ±296	768 ±247	1216 ±294	808 ±106	798 ±152
TSS	<20 ±2	<20 ±3	<20 ±2	<20 ±1	<20 ±2	<20 ±7	<20 ±6	<20 ±6	<20 ±4
COD	11 ±7	17 ±10	31 ±**41**	19 ±8	17 ±8	41 ±**59**	60 ±40	60 ±31	74 ±67
O & G	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chloride	323 ±95	396 ±99	290 ±145	348 ±95	266 ±120	197 ±62	214 ±79	156 ±72	278 ±132
Sulphate	52 ± 12	54 ±15	26 ±27	31 ±37	25 ±8	34 ±14.1	52 ±33	34 ±28	20 ±7
Phosphate	2.7 ±1.2	2.8 ±1.3	1.4 ±1.6	3.1 ±1.2	1.7 ±0.9	0.5 ±0.3	1.9 ±1.2	0.05 ±0.1	0.04 ±0.1

N.B. All Values except pH are in mg/L and rounded to nearest decimal, BOD was always less than 20 mg/L ; O &G was nil .

III. DISCUSSION

Efficiency of ETP is judged from reduction in concentrations of criteria pollutants (BOD/ /S.S./T.D.S/ O&G) for the industry. Permissible limits prescribed by pollution control board for both BOD & S.S. each is less than 100 mg/L, TDS less than 2100 mg/L and O&G less than 10 mg/L,COD 250mg/L, phosphate less than 5mg/L and permitted quantity of effluent @ 300 m^3/d.ETP performance depends on several design parameters e.g. i) hydraulic retention time, ii) mean cell residence time, iii) F/M ratio, iv)organic loading etc. These values were calculated for the existing ETP configuration and average flow to ETP @ 190 m^3/d. Hydraulic retention in bar screen tank ,O & G trap ,scrubber tank, equalization tank, diffused air floatation tank aeration tank and secondary settling tank were respectively 10minutes,50 minutes,19 hours,21hours(0.9 days) and five hours. F/M ratio was 0.21 for present flow and 0.11 for design flow @300 m^3/day. F/M ratio indicates that this activated sludge treatment plant was designed for

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extended aeration system but is being operated as complete mix activated sludge process. Percent removal of pollutants since 2009 till date is included in Table 4.

Table 4: Percent removal of pollutants in ETP

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
TSS	99	99	98	98	97	93	92	88	88
TDS	59	51	47	34	24	43	49	57	54
COD	98	98	98	98	97	97	95	97	96
BOD	95	98	98	98	96	91	97	94	96
O&G	96	97	92	97	96	77	88	90	89

A. Feasibility of recycle & reuse:

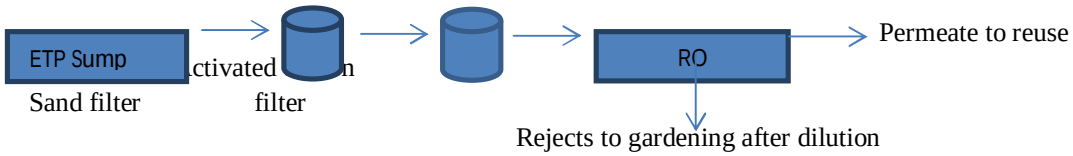
Plant management has been proactive towards environment management practices. Plant performance in terms of BOD/COD/O&G was above 90-95percent and that treated effluent quality has been consistently satisfactory. Industry therefore decided to verify feasibility of recycle and reuse of treated effluent in manufacturing processes. It would save would fresh water @about 150 m^3/d and also the revenue on water bills. Process-water- quality requirement in this plant is of demineralized and softened water. It was decided that effluent from existing secondary treatment in ETP be treated in a tertiary treatment plant. Tertiary treatment would aim at removal of residual organics and inorganics in dissolved and suspended state. Reverse osmosis system was finalized. Composited (flow weighted) ETP effluent samples were collected for 11 days and analyzed. Results are given in Table 5.

Table 5: Ionic composition of ETP effluent

Day	1	2	3	4	5	6	7	8	9	10	11	Mean
pH	7.3	6.7	6.5	7.2	7.1	6.8	6.1	7.5	7.3	7.4	7.5	6.5-7.5
Turbidity	9	15	18	10	8	4	12	19	20	17	5	12
TDS	369	1786	1176	1428	1285	986	800	750	729	458	456	927
Bicarbonate, HCO_3^-	39	120	129	154	142	156	142	112	110	118	101	120
Ca^{2+}	9	18	22	26	20	22	21	18	22	20	21	20
Mg^{2+}	78	22	12	31	32	31	32	28	28	30	29	32
Chloride, (Cl^-)	95	98	201	250	140	115	120	115	360	224	125	167
Sulphate, SO_4^{-2}	123	26	26	24	25	27	34	24	56	37	42	40
T. Silica, SiO_2	4	11	11	2	2	2	1	7	8	5	4	5
Phosphate,	2	<1	1	1	1	1	1	4	3	1.7	3	2
Fe,Cr,Mn, Pb,	Traces	Traces	Traces	Traces	Traces	Traces	Traces	Traces	Traces	Traces	Traces	-
COD	80	57	55	49	47	68	65	62	60	75	72	63
NB: All values in mg/L unless otherwise stated ; COD due to coolant traces												

Total ionic load in treated effluent based on average values is around 11.12 m eq. /L. Effluent is scale forming and quantity would be @ 235 mg/L. Probable composition of residue will be $CaCO_3$ -50 mg/L; Mg CO_3 -112 mg/L; Na_2 CO_3-14mg/L and Na_2SO_4-59mg/L . There is residual COD in the effluent. This composition of effluent indicated following flow sheet for tertiary treatment.

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RO plant has been commissioned and permeate is being used in process thereby saving fresh water @ about 170 m^3/d. Permeate water quality is given in Table 6.

Table 6: Permeate Characteristics of R. O. Plant

Parameter	Permeate										
Day	1	2	3	4	5	6	7	8	9	10	11
pH	6.8	5.4	5.3	6.2	7.3	6.1	6.1	6.2	6.4	6.2	6.1
Appearance/color	Clear/Nil	Clear/Nil	Clear/Nil	Clear/Nil	Clear/Nil	Clear/Nil	Clear/Nil	Clear/Nil	Clear/Nil	Clear/Nil	Clear/Nil
Conductivity (µS/cm)	Nil	5	5	5	4	5	5	5	4	5	Nil
Turbidity	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
TDS	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Bicarbonate, HCO_3^-	Nil	17	17	20	17	17	20	10	15	11	10
Ca^{2+}	0	0	0	0	0	0	0	0	0	0	0
Mg^{2+}	0	0	0	0	0	0	0	0	0	0	0
Chloride, (Cl^-)	0	0	0	0	0	0	0	0	0	0	0
Sulphate, SO_4^{-2}	0	0	0	0	0	0	0	0	0	0	0
T. Silica, SiO_2	0	0	0	0	0	0	0	0	0	0	0
Phosphate, PO_4^{-3}	0	1	1	1	1	1	1	< 1	< 1	< 1	< 1
Fe, Cr, Mn, Pb	0	0	0	0	0	0	0	0	0	0	0
COD	<7	<7	<7	<7	<7	<7	<7	0	0	0	0

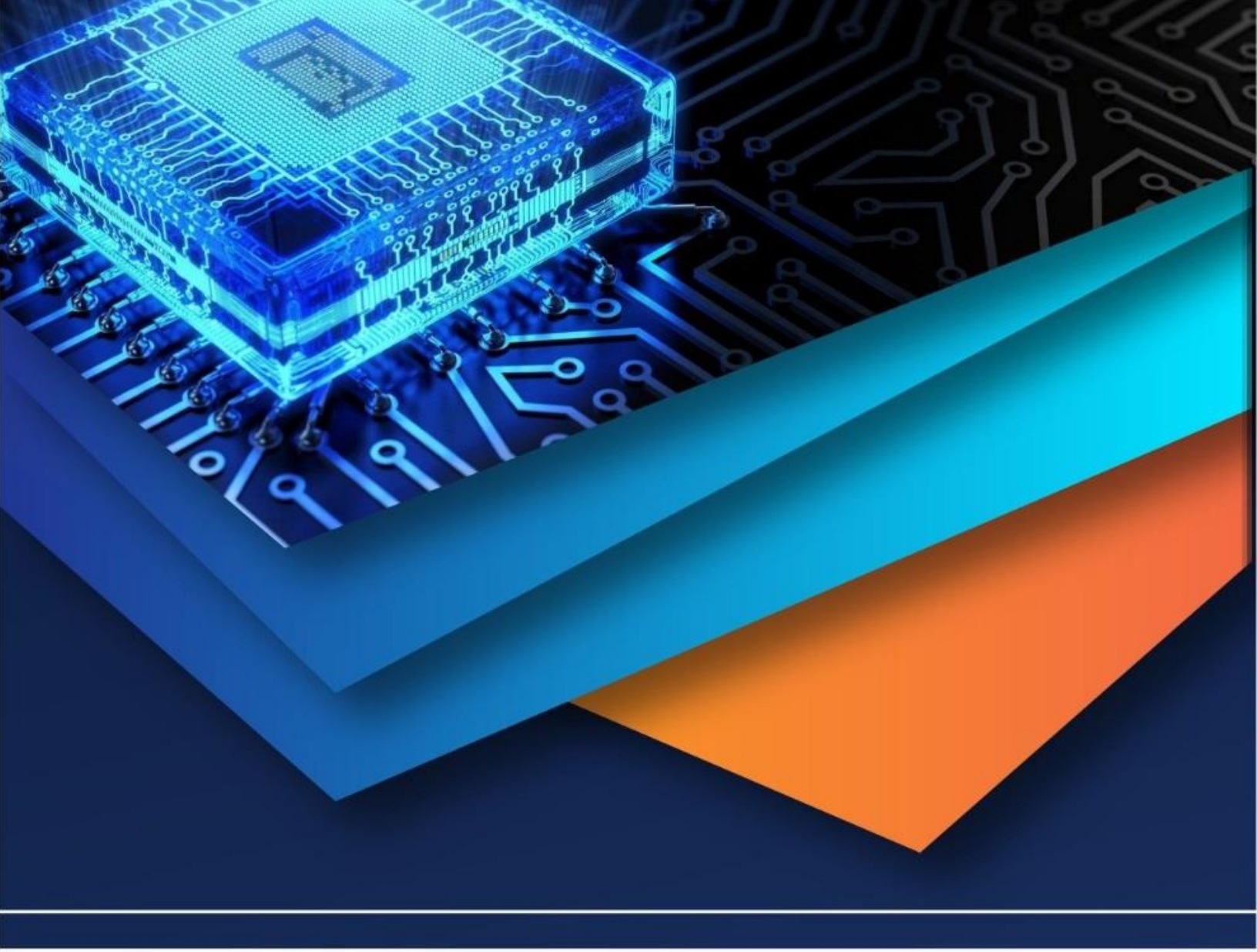
IV. CONCLUSIONS

Regular scientific monitoring for protracted period of a secondary waste water treatment plant at the industry has enabled the industry to conserve fresh water by recycle and reuse of treated effluent by a properly designed tertiary wastewater treatment plant. Effluent treatment plant design parameters like organic/hydraulic loading, BOD removal efficiency etc. were studied. Ionic load in treated ETP effluent was used for tertiary treatment plant selection and design.

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