Design of car wash waste water treatment plant using Electro-coagulation

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Abstract - *Car wash industry consumes tidy sum of water for laundry of cars. Effluent water generated from car wash station contains great amount of chemical characters they contribute an honest deal of environmental contamination. The effluent water carries different parameters like pH, turbidity, Chemical oxygen demand, oil and grease, were characterized for the collected car wash water. Oil and grease, Chemical oxygen demand contributes to the majority of pollution. The pilot study result show that electro-coagulation has better removal efficiency of oil and grease, Chemical oxygen demand, turbidity, total solids etc. The treatment plant comprised screening, grit chamber, collection tank, electro-coagulation unit, tube settler, pressure sand filter and carbon filter. Supported treatment results the treated water can reuse for under wash of cars and other washing purposes like cleaning of floor of car wash station. Each operation units dimensions are calculated are, flow is 0.25m3/ hr and every one chambers are designed rectangular sections except filtration units.*

***Key Words*: Car wash waste water, Electro-coagulation, pH, oil and grease, COD, TSS, TDS**

1. INTRODUCTION

Urbanization has made the opportunity for increasing the growth of automobile industry. Therefore, usage of bikes, cars, and truck are increased, and also they led to growth of automobile service stations. Automobile service stations are washing (exterior and interior) of vehicle, service and repair the vehicle parts. Based on survey of international car wash association around 100-200 liters of water is used for single car wash. That literally indicates that car wash industry consume large amount of water. Around all car wash stations they contain a fresh water source for washing purpose. In future consumption of fresh water is led to water scarcity problem. The car wash effluent water contains huge amount of contaminants like COD, TSS,TDS, turbidity pH , oil and grease etc. After washing of vehicle the effluent discharge in to near municipal sewers or water body which is decrease the water quality, harmfully effect on aquatic life. So it is very necessary to treat effluent water. The usage of water cannot be decreased, so it can be treating effluent water, recycle and also reuse the treated water. The study introduced electro-coagulation (EC) technique for removal of all contaminants and emulsified oil and grease, AL used as electrodes in electro-coagulation process. The treatment plant consists screen, grit chamber, EC unit, tube settler, and filtration unit (pressure sand filter and activated carbon filter). It's very necessary that treatment plant use less chemicals for treat water, eco-friendly, and sustain for long period. The main objective of project removes all contaminants and reuse of treated water.

1.1 Car wash technology

Car wash firstly started in 1914 at United Nations. It's also known as "automatic laundry". A car wash is defined as non-domestic installation for external leaning of car for get more attractive and clean. In early days the cars were impelled manually through a tunnel, workers are dispensed soap, washed, rinsed and dried by manually using hands. After revolutions the new technology are amended on the car wash systems. In 1946 Thomas Simpsons brought semi-automatic car wash system and on period of 1950-60 Anderson brothers discover fully automatic car wash on the same period India is firstly implemented car wash technology. Other inventions are soft touch, non touch, and rinse less car wash

1.2 Electro-coagulation

Electro-coagulation (EC) is an electrochemical process that simultaneously removes heavy metals, suspended solids, emulsified organics and many other contaminants from water and wastewater using electricity instead of expensive chemical reagents. EC is a technique used for waste water treatment, wash water treatment and medical treatment. Although the electro-coagulation mechanisms resemble chemical coagulation in that the cationic species are responsible for neutralization of surface charges. The produced flocks will tend to contain less bound water and more shear resistant, so it can more readily filterable. EC unit contain electrolytic cell, each with the pair of corrosive metal sheets (anode and cathode) these electrodes made up of aluminum or iron which can be organized, arrangements spacing and lengths, which depend upon removal efficiency. Anode continuously produce ions and need to be replaced, which are often called sacrificial anode, the plates are connected extremely a power source and immersed in the waste water, which supply electron current that drives chemical reaction at the electrode. The voltage needed for reaction occurs is called potential. Electric DC current cause various reactions, which facilitates dissolution, coagulation, flotation, flocculation, in EC source coagulation is cations produced by degradation of anode metal and activation energy applied, which promotes formation of oxides.

The process described below

- Anode : Al= Al+3e (metal=metal+electron)
- Cathode : 2H2O+2e H+2OH-

In electro-coagulation process pH important factor so pH should maintained 4.8 to 8. Caustic soda used for maintain pH and sodium chloride is used for increasing conductivity.

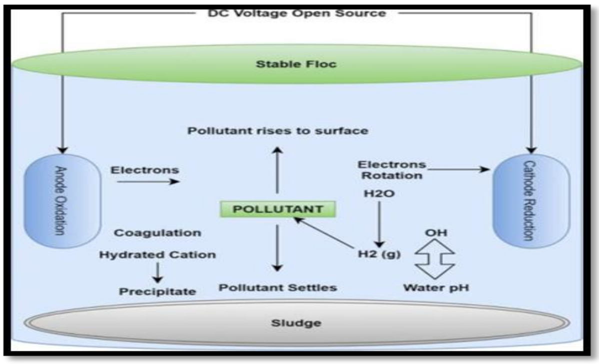


Fig-1: Electro-coagulation process

2. METHODOLOGY

Since the car wash industry discharge highly contaminated water so it's a necessity to seek out the parameters for remove them by suitable method and reuse the treated water for laundry purposes (under wash of auto and floor cleaning)

Steps are administered procedure within the project is given below:

- Sample collection
- Parameter analysis (pilot study)
- Design treatment plant

2.1 Sample collection

Car wash effluent water sample were collected from urban car wash station located at kadavantra. Waste water generated by washing of different cars. After washing the effluent water directly drained to municipal sewage treatment unit . The effluent water collected in a 1 liter plastic bottle.

Fig-2: Car wash waste water

2.2 Parameter analysis

The effluent sample collected and analyzed various parameters like BOD, COD, pH, TSS, TDS, dissolved oxygen, turbidity etc. well water is used as influent for washing of cars. The analysis values are shown below

Table–1: Parameter analysis of car wash water

Sl.No	Parameters	Influent water	Effluent value
1	BOD (mg/l)	4	136
2	COD (mg/l)	88.2	392.41
3	TSS (mg/l)	0	68
4	TDS (mg/l)	140	314
5	pH	6.53	8.63
6	Turbidity (NTU)	0	98.5
7	Dissolved oxygen (mg/l)	4	3.17
8	Total solids(mg/l)	100	382
9	Oil and grease (mg/l)	0	164

2.3 Experimental set up

Electro-Coagulation (EC) method is used for treating car wash waste water. EC reactor size of 0.75 m x 0.7 m x 1.5 m has been used. The reactor is made up of marine plywood with leakage proof. Aluminum used as electrodes (anode & cathode) with size 40 cm x 35 cm x 0.1 cm, and electrodes are places 1 cm spacing. The pH of effluent sample was maintained between 4.9 – 8.1 in EC reactor. DC power supply provided through a rectifier and voltage maintained by variac. The experimental set-up shows below.

Fig-3: Experimental set-up

2.4 Design of treatment plant

The treatment plant encompass different operations such as

- Screening
- Grit chamber
- Electro-Coagulation unit
- Tube settler
- Filtration (pressure sand and activated carbon)

The designing of all unit operations are done separately. As per data collected from urban car wash center using 3000 liters of water (from well) used for car wash and 500 liters water used for complete cleaning of car wash station. So total water usage is 3500 liters. According to KPCB consideration 80 % of total consumed water converted in to effluent water, so 2800 liter waste water produced in a car wash industry and 5% safety factor is provided. Therefore the capacity of treatment plant is 3 KLD. Total working hours taken as 12 hours. Then flow rate 0.25 m3/hrs. 100 L water consumed for single car wash.

Assume depth by width ratio of rectangular sections is 1.5, and also all comprised units are rectangular in section except filtration units they ate circular in section.

The design begins with collection tank,
Volume = 0.25 x 4 (retention period)
= 1 m3

As assume breadth as 0.951m then depth is 1.426m so the length is 0.724 m.

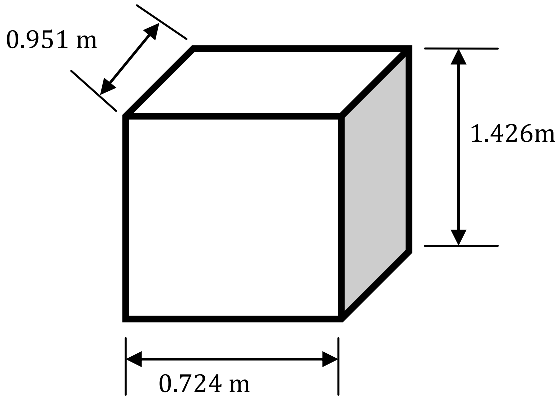


Fig-4: Collection tank

Screens are placed 60 degree inclination for retain large particles easily. Manually cleaned screens are used. Assume Surface over flow rate (SOR) as 2 m3/ hr m. Flow rate 0.25 m3/hr

Area of screen = flow rate / SOR
= 0.5 m2

Assume rectangular section Depth /width ratio is 1.5

Depth of channel = 1.5wxw {D/W=1.5) {area = 0.5}

Width of channel = 0.57 = 0.6 and Depth = 0.833 = 0.85

Length of channel = d x (Vh / Vs) assuming Vh and Vs 0.6 m/sec and 0.45 m/sec

Vs = settling velocity , Vh = horizontal velocity

= 0.85 x (0.6 /0.45)

= 1.133 m = 1.5 m

Assuming opening 3 cm wide and 1 cm thickness

Area of screen As = Area of channel / sin θ

= 0.5 / sin (50) , as θ is the inclination of channel it mostly taken 50 degree

= 0.653 m2

Net area (Anet) = As X S / (S+tbar)

= 0.653 x (3 / (3 + 1)

= 0.49 m2

From continuity equation

Va x Ac = Vb x Anet

Va = approach velocity

Vb = peak velocity or basin velocity

Vb = Va x Ac / Anet

= 0.6 x0.5 / 0.49

= 0.612 m/ sec

Check: peak velocity of screen should be less than 0.9 m/ sec, Here 0.612 < 0.9 m/ sec so it's ok

Head loss (HL) = Vb^2-Va^2 / 2 g C

C = Normal flow through a screen taken as 0.7

HL = 0.612^2-0.6^2 / 2 x 9.81 x 0.7

= 0.001 m

Assume 55 % clogged on screen

Net area = 0.55 x 0.49

= 0.269m2

Vb = 0.6 X0.5/ 0.269

= 1.11 m/sec

HL = 1.11^2-0.6^2/ 2 x 9.81 x0.7

= 0.063m

The number of bars screen = ntbar + (n-1) S = w -2

N = 14.75 = 15 nos

Dimension of bar screen 1.5 m x 0.85 m x 0.6 m =0.765m3 approximately 1 m3 with 15 bars with opening 3 cm and 1 cm having head loss 0.001 m with slope 60 degree.

Next unit operation is grit chamber they are mainly used to remove small particles like grit.

Flow rate = 0.25m^3/ hr and SOR = 2 m^3/hr/m

Area = 0.521 m^2

Length of channel = d / (Vh x Vs)

= 13.26 m

A weir provided in grit chamber for control water flow.

Y = Q / (Vh /W) Y = total weir length

= 0.1 / (0.3 x 0.580) = 0.574 m

Depth of weir (mm) = y = (2/3.1) x Y

= 0.383 mm

The weir must be shaped so that Q = 8.18 x 10-6 x w x y $^{1.5}$

Weir width w =51.576 m

Head loss = 36% x depth of channel

= 0.36 x 0.884

= 0.318m = 0.3m

Inlet allowance 30%

Dimension of grit chamber 13.26 m x 0.589 m x 0.884 m with free board 0.25 = 7.154 m3 weir width 51.576 m having head loss 0.3 m

After grit removal the effluent water led to move EC chamber, so design of chamber given below,

Flow rate =0.25 m3 / hr

Retention time = 0.5 hrs

Volume of EC units = 0.125 m3

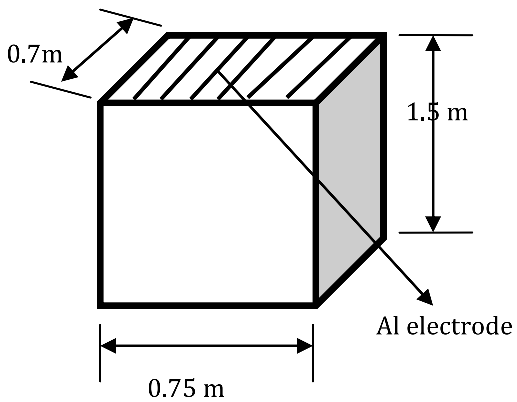
Area of EC = flow rate / SOR

= 0.25m3/hr / 2 hr m

= 0.521 m2

Provide depth = 1.5m width = 0.7 m length = 0.75 m

EC unit divided in to 6 chambers diving by FRP sheets of 3 mm thickness.



Aluminum is used as electrode and assume the dimensions are Length =40 cm =0.40 m, breadth = 35 cm = 0.35m thickness = 0.1 cm = 0.01 m

After EC operation generated sludge allows for settling for that they were led to flow in to tube settler. Sutro-weir provided inside tube settler to convert sludge particles transition flow to laminar flow for easy settling of particles and for boosting settling process added polymer with 0.035 gm. Design of tube settler described below, Flow rate = 0.25 m3/ hr

Relative length of settler = l / d

Assume l = 1m and d = 0.05m

Relative length = 1 / 0.05

= 20m

L' = 0.058 x (Vo / υ) x d

= 0.058 x (Vo x 0.05 / 1.01 x 10-6)

= 2.87 x 10^3Vo m / sec

= 0.0332 Vo m/ day

Effective length = (l/d) – L'

Sc = (Vs / Vo) x (sinθ – cosθ)

For rectangular section critical value = 11/8 and assuming settling velocity 120 m/day.

11/8 = (120/Vo) x (sin (60-(20 – 0.333 Vo)- cos (60)

X (10+0.0165))

Solving above Equation for find Vo

Vo = 388.6 m / day

Total entrance area of tube = Q/Vo

= 2.893 x 10-6 / 4.497 x 10-6

= 0.6433 m^2

Assume d/w = 1.5

D = 0.982m and w = 0.654m

Volume 0.25 x 4 hrs (detention period)

=1 m^3

Length of tube settler = 1.58 m

Dimension of tube settler = 1.58 m x 0.654m x 0.982m

They bottom provide 60 degree ground inclination

After settling the water led to flow in to pressure sand filter and activated carbon filter. They are in circular in section and the dimensions are;

Flow rate = 0.25 m3 / hr

Retention time = 2 hrs

Volume = 0.25 m3/ hr x 2 hrs

= 0.5 m3

Area = 2 π r h

Height (h) = 0.976 = 1 m

Radius (r) =0.082 m = taken 0.4 m

Diameter (d) = 0.2 m

Dimension of filters = 0.2 m diameter x 1m height

Table–2: Properties of filter units

specification	Pressure sand filter	Activated carbon filer
Flow rate	0.25 m /hrs	0.25 m /hrs
Filtration rate (assume)	15 m3/ hr m2	13 m3/ hr m2
Height of straight provide (standard)	1.65 m	1.65m
Volume (standard)	20 m	20 m
Diameter	4 m	4m
Media	Sand and gravel	Activated carbon with IV>900

After complete treatment treated water collected in a treated water tank which designed as;

Flow rate = 0.25 m3 / hrs

Retention time = 4 hrs

volume V = 0.25 x 4

= 1 m3

Area = flow rate / SOR

= 0.512 m2

Depth/ width ratio = 1.5 then width = 0.6m depth = 0.85m length = 1.95m

Dimension of treated water tank =2 m x 0.6m x 0.85m

2.5 Estimation

The treatment plant is made up of concrete and steel. Final estimate include fixed cost and running cost of the system. 20 bags of cement, 1.5 tone sand and 0.20 tone gravels are used. The estimate values shows below ;

Table–3: Total cost of unit operations

Items	Volume	cost	Total cost
Bar screen	1m3	15,000	15,000
Grit chamber	7.152m3	15,000	1,07,280
E C unit	0.787 (30 units)	20,000	6,00,000
Tube settler	1.5	25,000	37,500
Pressure sand filter	20 (4mdia &1.65 height)	2500	50,000
Activated carbon filter	20 (4m dia & 1.65m height)	4000	80,000
Collection tank	3	15000	45,000
Treated water tank	1 m3	15,000	15,000
Filter tank	0.5 m3	20,000	10,000

Dosage of pump = 10 (5 stand by) { 0.25 hp consumption with 4 hrs}

E C unit = 0.5 Hp (for 20 hrs = 10 hp)

Pressure sand filter = 16 Hp

Total Hp = 27 HP

Rate of 1 unit current =8 /-

Cost of current per day =27 x 8 =216/-

Per month =6480 /-

For an year current consumption cost = 77,760 /-
The electrode charges are;

Cost of aluminum = 400 / kg
Consumption of electrode =I X T X M / (F X N) x V

I = current T = time uses M = molar mass Al F = faradays constant (96485.3329)
N = no of electrons in oxidation process V = volume
Consumption = 60 x (24x60x60) x 26.89 / (96485.3329 x 3 x 30)
= 0.0034 kg /m3
Per month = 0.0034 x 30
= 0.102 kg / m3
In case of Al =0.102 x 400 =40.8/- = 41/-
Per month = 41 x30 =1230/- 4 electrode used with 14 sets total =56
Total cost = 56 x 1230 = 68,880/-

Chemical consumption cost
Consumption of caustic soda 0.03-0.035 g/ L
Assuming the cost of caustic soda =32 /- (day)
For month = 32 x30 = 960/-
Chemical consumption cost for an year= 11,520 /-

Labor charge for a year = 5,56,000 / year
Sludge disposal cost for a n year= 15,000/-
Generator (stand by) = 85,000/-

Total cost of treatment plant is 25,5,0940 /-

3. RESULT AND DISCUSSION

Electro-Coagulation (EC) is most efficient method for removal of contaminants and oil and grease.

- Firstly car wash effluent water shows alkaline character after treatment that became neutral character.
- Car wash water shows high oil and grease after treatment that removed 93.54%
- COD, turbidity and TSS are highly present in car wash effluent water. later treatment process they removed more than 70%

The variation of effluent water before and after EC process shows below table and graphical representation;

Table–4: Parameters before and after treatment

SLno	Parameter	Car wash water{mg/l}	After electro coagulation	Percentage of removal efficiency
1	BOD	136	30.23	77.772 %
2	COD	392.41	90.12	77.34%
3	Dissolved oxygen	3.17	8.1	60.86 % back to water

4	pH	8.63	7.2	-
5	Oil and grease	164	10.59	93.54%
6	Total solids	382	90	76.439 %
7	TDS	314	62	80.25 %
8	turbidity	98.5NTU	10	89.84%
9	TSS	68	2	95 %

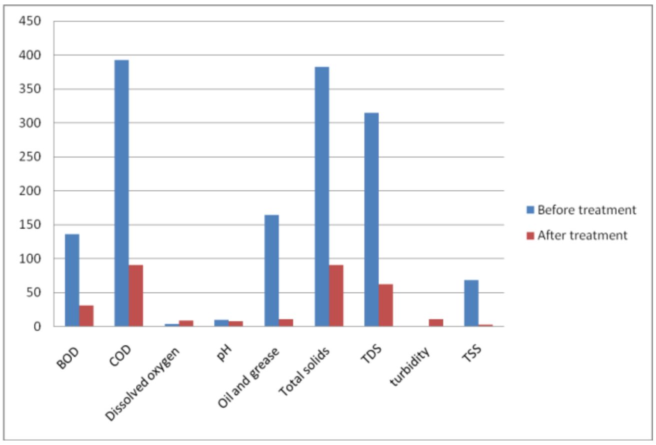


Chart -1: Before and after treatment of effluent water

The table 4 and chart 1 shows effluent water parameter variation before and after treatment process and also shows the percentage of removal efficiency of EC. The result shows that most of the contaminants are removed through EC process and the water quality become normal so it can be used for reuse or back washing. Although EC is removes pathogens so the treated water can be used for gardening process. Comparatively EC is one of the method eco-friendly and less usage of chemicals.

4. CONCLUSIONS

Water demand increases day by day so the quality and quantity became diminish tidy sum rate. In car washing station reuse and recycle of water is a sustainable solution for water scarcity problem and urban water demand. This project reveals that EC contain AL electrode is the most effective method for removes contaminants in car wash water. EC is simple and eco-friendly method, cost effective method compared to other recycle method. It need less human power and chemicals for treating effluent water. EC is integrated technology provide clean and less space.

Analyze overall result EC provide more than 75% removal efficiency. So the treated water can reuse with eco-friendly. The sludge produced after treatment can be disposed in eco-friendly .because they contain less harmful substance rather than its applicable limit.

After analysis final result more than 75% of water can be recycle and reuse they reduce water pollution and environmental pollution.

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