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Waste management strategy of a fertilizer plant

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Abstract

The paper presents the study to understand evaluate and examine the different pollution abatement strategies of Indian Farmer's Fertilizer Cooperative Ltd. It also includes the identification, types and means of various pollution hazards and to sutdy the abatement strategy of different pollutants.

Introduction

Indian Farmer's Fertilizer Cooperative Ltd. (IFFCO) is one of the fastest growing fertilizer industry of India. At present its four plants are operating in the country. IFFCO was established on 3rd November 1967. The plant is situated at a distance of 28 km. South-West of Bareilly on Bareilly Aonla road in Uttar Pradesh.

The total capacity of Aonla Unit including both phases is 8, 91,000 MTPA for Ammonia and 14,52,000 MTPA for Urea (EMIAU 2000).India uses about 16 kg. per hectare of fertilizer while the world average is 55 Kg. per hectare (Sharma and Kaur 1997). A typical fertilizer unit in India produces 300 tons per day of ammonia, 300 tons per day of Urea, 1100 tons per day complex fertilizer and 130 tons per day of Methanol (Mahajan 1985). According to eminent soil chemist, Dr. H.H. Koepf, modern agriculture can honestly claim two notable crops "disease and pests" but now a third factor " Poison" (as NO_2,NO_3etc.) can be frequently added. Therefore due to high level of toxicity proper management and disposal of effluent is necessary. The Knitting of productionwith environmental protection is the unique feature of Aonla unit. This new technique has eased out various problems of environmental management. The technology of the plant is based on recycle and reuse of the effluent to achieve Zero effluent discharge from plant.

Considering these problems study has been made as Environment Management Strategy and results are presented in paper.

Materials and Method

Management of environment confers utilization of resources prudently so that waste generation is minimized. The environment management at IFFCO aims for abatement of pollution at the source itself.

The various plants and sectors which are running at IFFCO Aonla unit with their capacity are as follows:-

Plants	Capacity
1. Ammonia plant (2no.)	2* 1350 MTPD
2. Urea plant (4No.)	4* 1100 MTPD
3. Utilities	
(a) Steam Generation service boiler .	1* 1500 MT/hr.
(b) Gas turbine Generator (2No.)	2*25 MW (ISO)
(c) Water treatment plant	6*140 M^3/hr.
(d) Inert gas Generation	600 Nm^3/hr.
(e) Ammonia storage tank	4* 10,000 MT
4. Centralized effluent treatment plant	
(a) Cooling tower blow down treatment	480 m^3/hr.
(b) Ammonia bearing occasional waste treatment	120 m^3/hr.
5. Urea bagging plant	8 slats of 250 MT/ hr./slat

The study has been made to examine the various abatement strategies of pollution at IFFCO Aonla unit with the following objectives:-

1. To identify various pollution hazards.
2. To identify the types and means of pollution i.e. sources of pollution
3. To study the abatement strategy of different pollutants.
4. To study the environment strategy at IFFCO Aonla.
5. To develop an alternative strategy in existing system. and
6. To ensure awareness among factory employees about the environmental pollution.

Liquid Waste Management at IFFCO Aonla

To achieve zero effluent from Ammonia plant based on Halder Tapsone Technology has process condensate stripper, Turbine condensate, Boiler blow down, Disc oil separator.

The urea plant is based on Snam Progetti technology having waste water treatment section

(A) Process condensate stripping section: This section treats process condensate from two separators and excess condensate from CO_2 removal section. The condensate stripping removes a substantial part of NH_3, CO_2 & Methanol from condensate before the treated condensate is passed to demineralised plant (Fig 1)

Both NH_3 & Methanol together with CO_2 enters the process condensate according to following reactions:-

$$\text{(i) } NH_3 + H_20 = NH_4^+ + OH^-$$

$$\text{(ii) } CO_2 + H_2\,O = HCO_3 + H^+$$

$$\text{(iii) } 2HCO_3^- = 2CO_3 + H_2$$

$$\text{(iv) } NH_3 + HCO_3^- = NH_2\,COO + H_2O$$

In the reforming section methanol & ammonia will undergo chemical reaction and end up as N_2, H_2 & CO_2. The stripped condensate is finally cooled to 45°C before sent to deminerelised plant.

(B) **Treatment of turbine condensate:** Turbine condensate which comes from condenser is contaminated with small quantity of dissolved and undissolved solids. It is treated in condensate polishing section which consists of:-

(i) Activated carbon filter section:- Two no. of activated carbon filter are provided for removal of methanol, oil, grease, diethylamine and other undissolved & organic matter. Regeneration of carbon filter is done once in every 48 hrs.

(ii) Mixed bed unit :-Two no of mixed bed unit are provided for treating return con densate. Cation and anion (mainly Na^+, K^+, Ca^{++} etc.) are removed in this unit.

(C) Treatment of Boiler blow down:- The boiler blow down in flashed in a blow down vessel, where flashed saturated low pressure steam is separated from steam condensate.

(D) Treatment of oily water:- Here the spilled oil is collectd through underground PVC pipes to oily water basin where oil and water forms two phases with oily layer at top. Here oil is skimmed off with the help fo Disc oil seperator and is transferred to slope oil tank. Waste water is pumped to neutralization pit.

(E) Treatment of ammonia and urea bearing water in urea plant:- The exhaust solution from stripping column containing mainly Urea os fed to deep hydrolyser operating at 36 ata pressure

On hydrolysis urea is broken down into NH_3 & CO_2.

$$NH_2.\ CO.\ NH_2 \xrightarrow{H_2O} 2NH_3 + CO_2$$

The hydrolyzed solution is fed to distillation tower where ammonia & carbon dioxide is distilled out by low pressure steam. The treated water is used as cooling tower make up.

(F) Treatment of acidic and alkaline waste:- Ammonia and water treatment plants are having ion exchangers. The water which comes from cation exchangers contains lot of free mineral acids, salts of corresponding acids viz. HCl, H_2CO_4, H_2CO_3, NaCl, $CaCl_2$ etc.

Similarly, the water which comes through anion exchanger contains sodium salts of weak and strong acid viz. NaCl, Na_2SO_4, and $Na_2\ SiO_3$. To neutralize acid waste 5% HCI solution is used neutralization pits are connected to centralized effluent treatment plant.

$$2\ ReH + CaSO_4 \longrightarrow Re_2Ca + H_2SO_4$$
$$ReH + NaCl \longrightarrow ReNa + HCL$$
$$Re_2Ca + 2HCI \longrightarrow 2ReH + CaCl_2$$
$$ReNa + HCI \longrightarrow ReH + NaCl$$

Formation of sodium salts of weak & strong acid in anion exchanger:-

$$ReOH + HCI \longrightarrow ReCl + H_2O$$
$$2ReOH + H_2SO_4 \longrightarrow Re_2SO_4 + 2H_2O$$
$$2ReOH + H_2CO_3 \longrightarrow Re_2CO_3 + 2H_2O$$
$$ReCl + NaOH \longrightarrow ReOH + NaCl$$
$$Re_2SO_4 + 2\ NaOH \longrightarrow 2\ ReOH + Na_2SO_4$$
$$Re_2SiO_3 + 2NaOH \longrightarrow 2ReOH + Na_2\ SiO_3$$

(G) **Treatment of cooling tower blow down & occasional waste by centralized effluent treatment plant:-**

Ammonia and urea plant are having separate cooling towers which uses chromate based corrosion inhibitors. The chromated cooling tower blow down is treated in effluent treatment plant which is designed to:-

(i) Remove Hexavalent chromium from cooling tower blow down:

Cooling tower blow down contains following contaminants-

Ca as Ca CO_3	144 ppm
Mg as Mg CO_3	96 ppm
Na as Na_2 CO_3	1448 ppm
SiO_2 as SiO_2	120 ppm
Cr as Cr^{+6}	14-16 ppm
Free chlorine as Cl_2	1.0 ppm

Impurities are treated in chromate reduction plant measured amount of conc. H_2SO_4 & ferrous sulphate at suitable conc. is dosed in to blow down water (H_2SO_4 is added to control the blow down pH in the range of 2-3.5. Because this process progresses rapidly at low pH & reaction end point is more distinct at low pH.

Finally in chromate reduction pond the hexavalent chromium reduces to trivalent chromium.

The effluent is then collected in precipitation pond. In this pond, alkali (lime) is added to elevate the pH to 9.0, where trivalent chromium and iron is precipitated out as hydroxide of corresponding metal.

Reduction pond:

$$Na_2\,Cr_2\,O_7 + 6FeSO_4 + 7\,H_2SO_4 \longrightarrow Cr_2(SO_4)_3 + 3Fe_2(SO_4)_3 + Na_2SO_4 + 7H_2O$$

Precipitation pond:

$$Cr_2(SO_4)_3 + 3\,Ca\,(OH)_2 \longrightarrow 2Cr(OH)_3 + 3\,Ca\,SO_4$$

$$Fe\,(SO_4)_3 + 3\,Ca(OH)_2 \longrightarrow 3Fe(OH)_3 + 3\,CaSO_4$$

Chemical consumption

Ferrous Sulphate	1614 Kg/day
Lime	1625 Kg/ day
98% Conc. H_2SO_4	1222 Kg/day

Used for flow of 480 m^3/hr. of cooling tower blow down to chromate treatment plant. Now the precipitated liquid is transferred to clariflocculator where the solids can be agglomerated in to fast settling particles by adding coagulating agent i.e. Alum. The clear water is taken to guard pond and sludge separated in centrifuge is dumped in sludge pits.

(ii) Treatment of occasional waste from Ammonia & urea plant:- During normal operating conditions, there is zero effluent generated from urea plant except floor washing. But during abnormal condition ammonia bearing waste from urea or ammonia plant is collected in to contaminated effluent from demineralising plant and lime solution is added at controlled rate to maintain pH about 11. The effluent after filteration is sent for stripping of free ammonia. The air stripped effluent is further heated and residual ammonia is further removed by steam stripping with low pressure steam stripper. The treated effluent is sent to " **Treated effluent lagoon** " These ponds are quite safe from environmental angles as they are double line PCC with polyethylene sheets.

(G) Treatment of sewage waste:- Two no. of oxidation ponds are installed to treat sewage from township. In this aeration is carried out to ensure the dissolved oxygen content of waste water. The water thus obtained is used for irrigation purpose.

Air Pollution Management at IFFCO Aonla

(i) Analysis of Gaseous Pollutants:- There are 5 primary pollutants which together contribute more than 90% of global air pollution these are (i) Carbon monoxide (CO)(ii) Nitrogenoxides $(NO)_x$(iii) Hydrocarbons $(HC)_x$(iv) Sulphuroxides $(SO)_x$ (v) Particulates.

At, IFFCO, the concentration of sulphur being negligible in natural gas obtained from Bombay high basin the SO_2 concentration. in flue gases remains in traces.

To assess concentration of pollutants IFFCO Aonla, separately incorporated SO_2 & $(NO)_x$ analyzer, apart from this CO, O_2 analyser and High volume air sampler are also incorporated. The stack height of steam generation service boiler flue gas stack is kept at 120m for efficient dispersion of plume.

(1) Dedusting system at urea prilling tower:- The air loaded with urea sublimate from prilling tower enters the dedusting system at point A, and escapes the plant at point B with clear air quality. (Fig.2)

The urea dedusting containing gas is scrubbed by lean urea solution which is circulated by pumps. The scrubbing liquid enters the scrubber and is distributed by means of nozzles to become drops with a large absorption surface. This at the same time produces a pressure gain causing at suction connection (A) of the scrubber a suction pressure which sucks off exactly whereby the desired absorption surface is obtained. After escapes at point B into atmosphere containing 5ppm of urea dust. The liquid is collected in a reservoir thus, urea solution can be recovered & extracted at point F. Process condensate water is fed in at point E.

Land Management at IFFCO Aonla

Land management includes both the soil development and solid waste management

(i) Soil development and afforestation:- Initially the soil of the land of IFFCO was highly alkaline in nature with higher content of clay and barren for agricultural purpose but after treating the soil with pyrite along with Gypsum and finally made for plantation. They use 336 acres of total land out of 1273 acres for plantation. IFFCO Aonla developed their social forestry farm. As a result at present there is 80 m wide green belt around the factory and 250 m towards township & additional afforestation is in progress with about 1.5lac tree plantation.

(ii) Solid waste disposal & management:-

(a) Solid waste from plant:- One of the solid waste from plant is hexavalent chromium which after treatment is dumped in to sludge pit which is safe from environmental point of view.

(b) Solid waste from township:- Solid waste collected from township is dumped into low line area to maintain the level of the land.

Noise pollution management at IFFCO Aonla

In IFFCO to control the pollution through noise there is a regular checking of heavy machines such as pumps, motors, compressor and structure support of different machines. There is also a regular checking of vibrations and knocking through machines. To avoid noise pollution there is regular maintenance of producing sources such as greasing, oiling of machines etc.

Control Methods as described by Gupta & Singh (1988) were used for the above study.

Standard Parameters like pH, free ammonia, urea, total Kjeldahl nitrogen, BOD, Oil and grease, SO_2, NOx chromium were selected for the study. Methods as described by APHA (1985) & Trivedy & Goel (1986) were used.

Result and Discussion

Flow sheet showing interconnection among plants and treatment facilities is shown in Fig.3

The values of various important parameters which were studied are shown in Table 1 & 2. The graph shows the amount of pollution decrease during the year 1995-96 to 1998-99.

The strategies of the Present study have already been described above. The value of free ammonia in treated effluent was found to be 0.99 mg/1. The value of pH was recorded as 7.6.

The quantity of raw water demand and effluent discharged was found to be 4056400m^3 and 393085.8m^3. While according to Gupta (1997) the quantity of raw water discharged was 437111m^3 and 393085.8m3 for quantity of discharged effluent. Here the loss in the quantity of discharged effluent shows the better utilization of effluent from plant (Figure 4&5).

The value of B.O.D. was found to be 12.6 ppm while the MINAS (1985) was given as 30.0 ppm. Saxena and Mehra (1989) found Kjeldahl Nitrogen in fertilizer plant effluent as 150mg/1 while comparing to IFFCO value it is only 23.69 mg/1 which is within the prescribed limit.

Due to effective environmental managment system, the treated effluent and ambient water quality is maintained.

From the above data, we can conclude that with the effective pollution and environmental management system at IFFCO Aonla unit, the quality of final effluent after treatment and ambient air quality is well with in the limits.

Conclusion

After evaluating and analyzing the various pollutants and pollution control measures at IFFCO Aonla, the following conclusions can be drawn-

(1) The utilization of treated waste water in irrigation practices is unique of its kind. The philosophy of utilization can be extended throughout the conutry, therof utilizing the pre cious natural water resources.

(2) A study is needed for gainful utilization of solid waste (i.e. chromium hydroxide, $CaCO_3$, NaOH) as raw material for dye and pigment industries.

(3) Acid and alkali, utilized for pH balancing can be replaced with CO_2 gas.

(4) Development of green belt around the factory to reduce the percentage of carbon dioxide in the ambient air.

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Table No. 1

	Average value of treated effluent analysis (in μgm/Nm^3)
Parameter	Result of analysis
pH	7.6
T.K.N.	23.69
Free ammonia	0.99
B.O.D.	12.6
Hexavalent chromium	NT
Oil and grease	NT
Nitrate	1.67

Table No. 2

	Average value of ambient air quality (in gm/Nm^3)
Parameter	Result of analysis
Sulphur dioxide	NT
Nitrogen oxides	17.10
Ammonia	50.50
Carbon monoxide	NT
Suspended Particulate	135.05
Urea dust	180.0

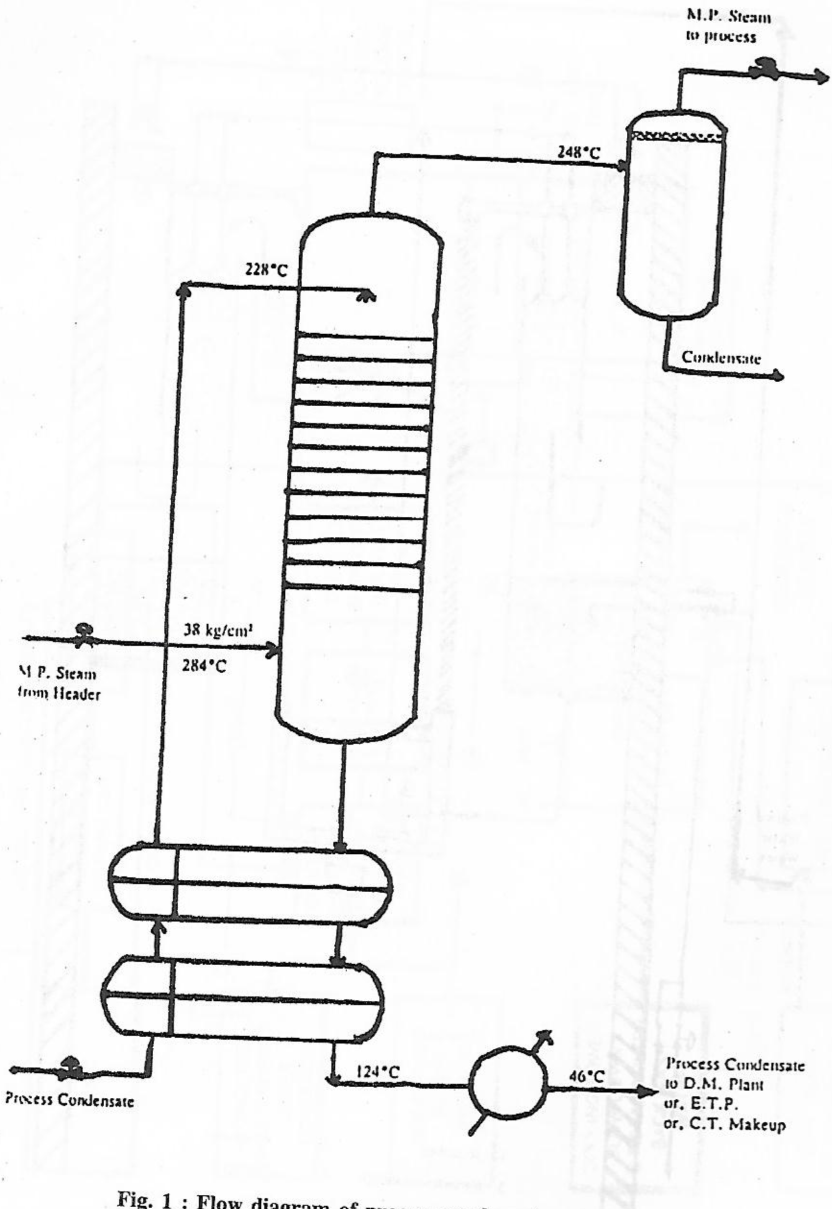


Fig. 1 : Flow diagram of process condensate stripping section

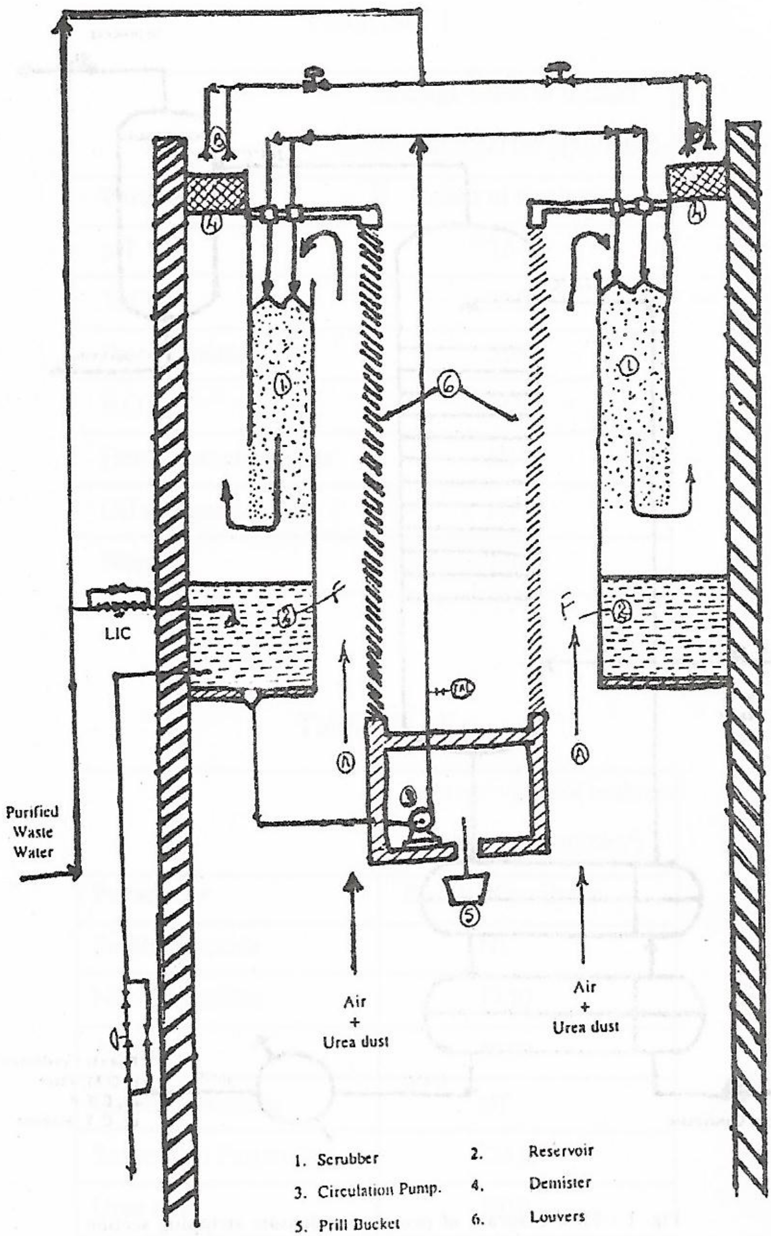


Fig. 2 : Flow diagram of dedusting system of urea prilling tower

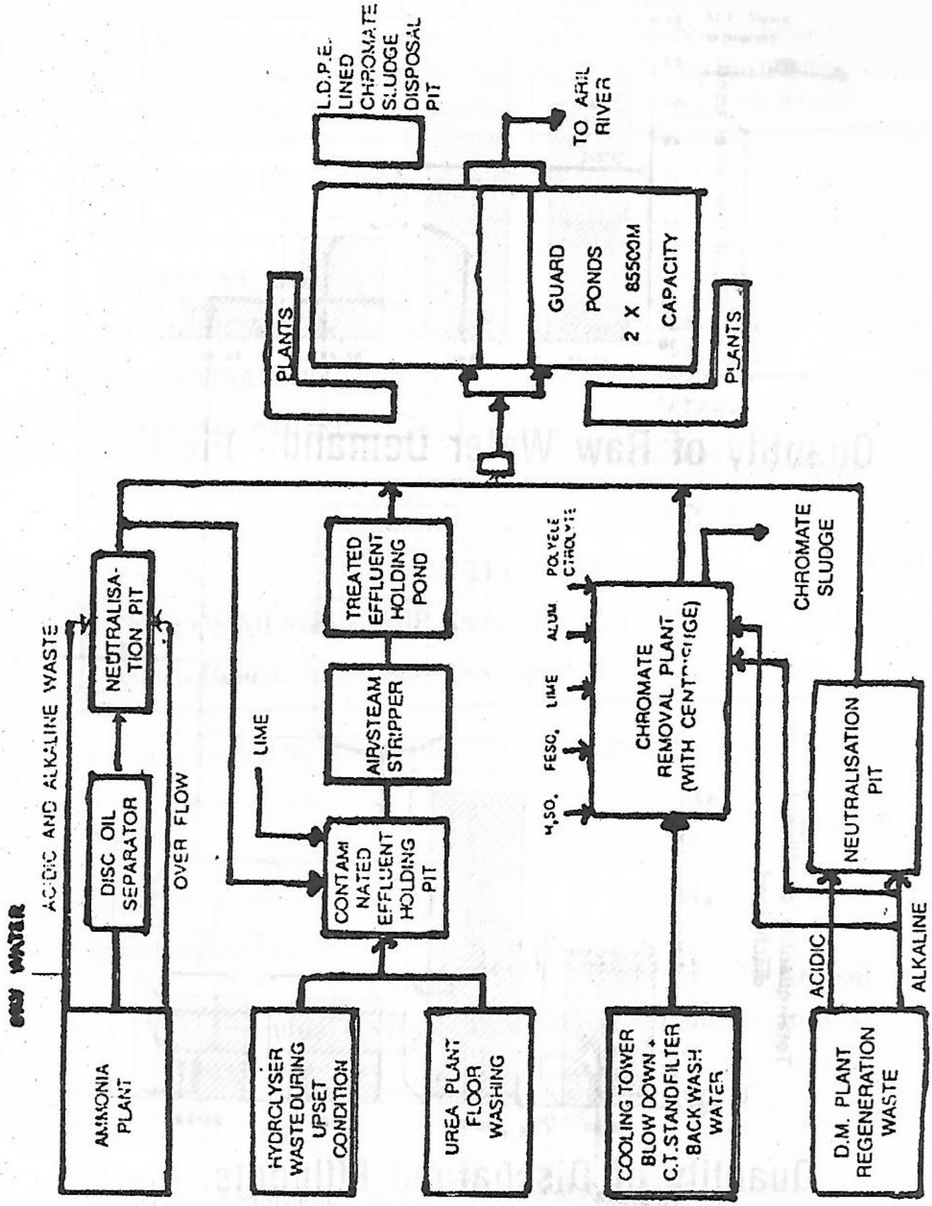
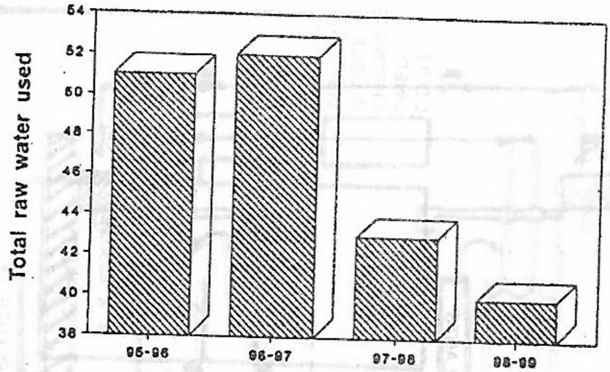
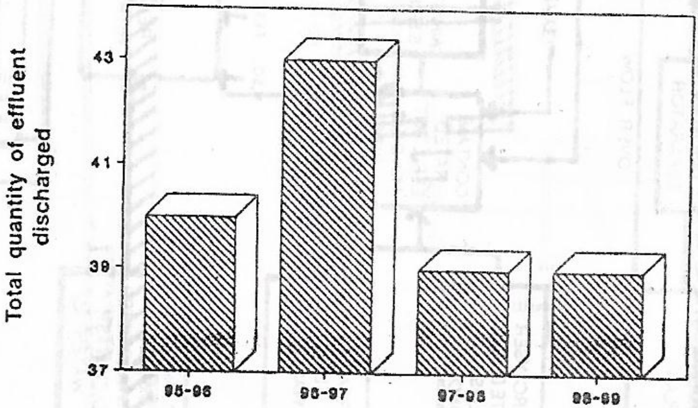


Fig. 2 : Flow diagram of pollution control measure at IFFCO Aonla



Quantity of Raw Water Demand. Fig.4



Quantity of Discharged Effluents. Fig.5