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ASSISTANCE IN WATER AND WASTEWATER TREATMENT IN THE FOOD INDUSTRY IN THE SYRIAN ARAB REPUBLIC

PART 4

DREKISH WATER FILLING FACTORY

FINAL REPORT

ZAGREB, JULY 1988.

27/5

PROJEKT - RIJEKA

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PART 4.

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1. GENERAL DATA

The two products of the Drekish water filling factory are: mineral water and a carbonated cola drink.

The factory is situated in the town of Drekish, not far away from Tartus harbour. It was built in the fifties and now about 150 workers are employed there. They work in a single shift during winter time and in double shifts in summer.

The maximum production capacity is:

- 780.000 Boxes of mineral water/year (45 cu m/day in winter time and 90 cu m/day in summer time)
- 1 000 000 small boxes of cola/year

2. DESCRIPTION OF PRODUCTION PROCESSES

2.1. MINERAL WATER TREATMENT AND PRODUCTION

(See Simplified Process Flow Diagram on Fig. 3.1.)

The mineral water well is situated on a hill about 600 m air-line from the factory. Water is sucked from about 130 m depth by a pump whose capacity is 4 cu m/hr (P1). The pump works 24 hours per diem. The daily quantity of the sucked natural mineral water is about 95 to 100 cu m which is almost half as much than required in winter time. The surplus water is taken through the overflow on mineral water tanks to the reception tank T-3 of so called industrial raw water.

The mineral water tanks (T1 and T2) are placed near the factory, approx. 200 m far from the production hall, each having the volume of 25 cu m. From there, natural mineral water gravitationally flows into the smaller tank (V = 2,4 cu m), placed in the hall by the production line (T1).

From that tank, water is pumped (P3 - pump capacity being 10 cu m/hr) to the pressure sand filter (F1), after which the process of ozonization takes place. The process completed, water is filtered again (F2 or F3), and finally bottled into plastic bottles, the volume of each being 1,5 l.

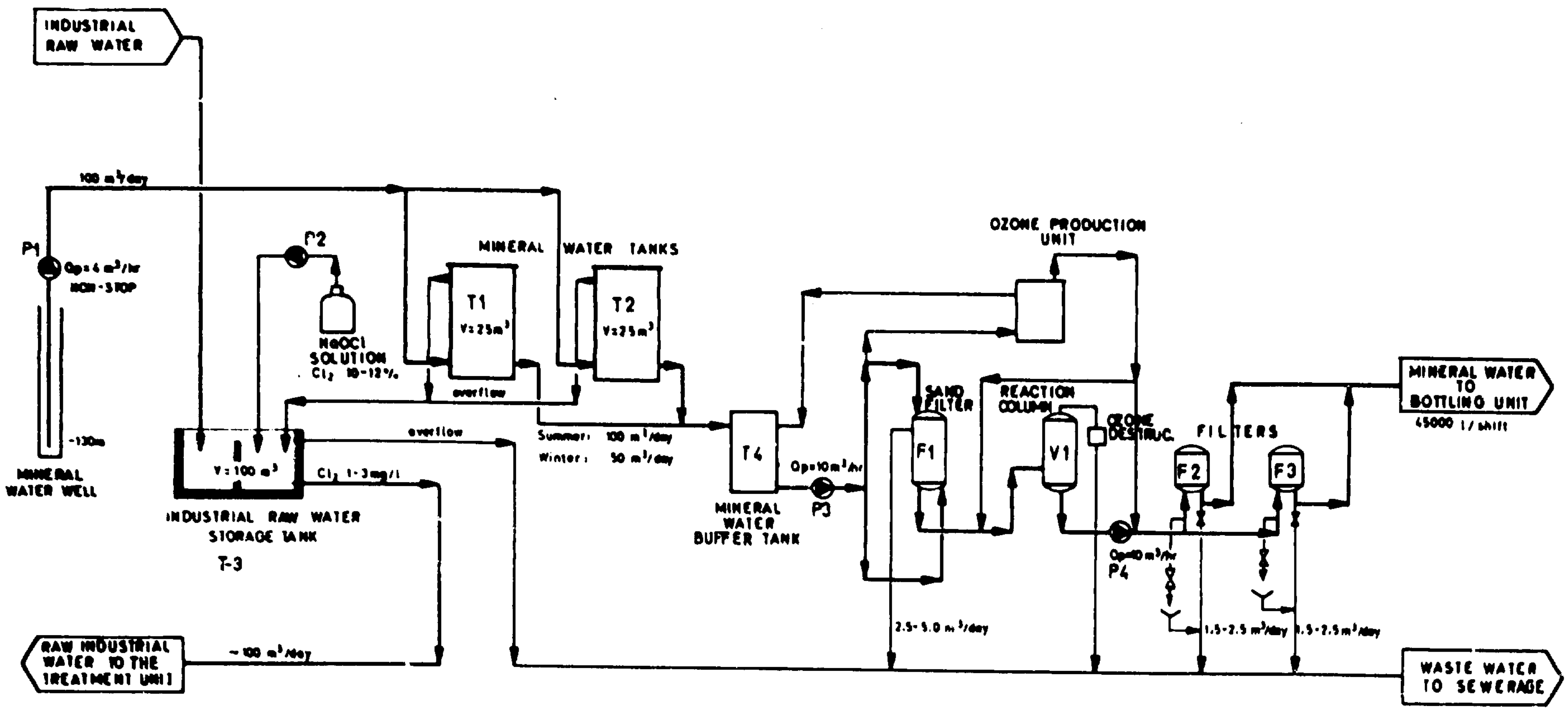


FIG. 3.1. SIMPLIFIED PROCESS FLOW DIAGRAM OF MINERAL WATER TREATMENT (existing)
Drekish Water Factory

The bottling line capacity is 45 000 l/shift. During summer double shifts are in operation, while in winter only one shift operates.

2.2. COLA PRODUCTION

The cola production starts with the preparation of the concentrate. Only then the concentrate is diluted by water, CO_2 is added and water is bottled on the filling line.

Glass bottles are returnable, and washed in the factory on the automatic washing line.

The washing process undergoes five stages:

1. stage - soaking and pre-washing in the effluent of final rinsing

2. stage - washing with 1,5-2 % NaOH solution

3. stage - washing with 2-2,5 % NaOH solution

4. stage - washing with solution which contains 1,0-1,5 % NaOH and 3 % H_3PO_4

5. stage - rinsing with clean water until a neutral reaction to phenolphalein paper appears. The water returns to the first phase for re-usage.

Washing substances from the stages 2,3,4 are recycled and are disposed of periodically (approx. after every 6 to 10 working days) in total amount of 15-20 cu m.

3. INDUSTRIAL WATER TREATMENT AND DISTRIBUTION

3.1. GENERAL DESCRIPTION

(See Simplified Process Flow Diagram, Fig. 3.3.)

Raw industrial water is supplied from a spring in a cave 8 km away. Water is transported gravitationally through a pipe from the cave to the pump station 1 km away, and then it is pumped up to the tank on a nearby hill (approx. 200 m above the pump station). From the tank water gravitationally flows to the industrial raw water concrete tank (V = approx. 100 cu m) within the factory (see ilustration on Fig 3.2.).

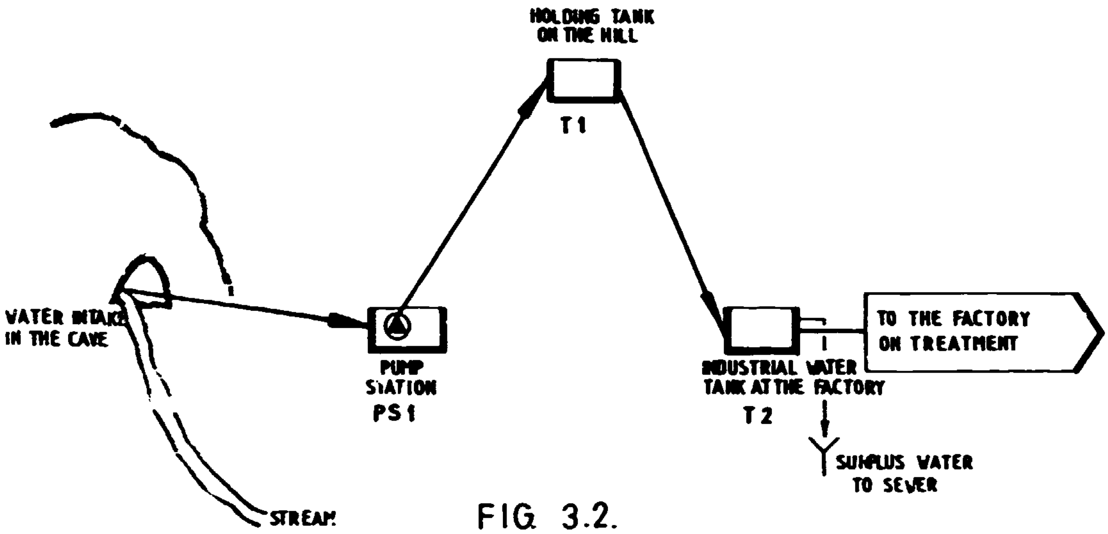


FIG 3.2.

Water is then disinfected with a 10-12 % NaOCl solution. From the data obtained in the factory, residual chlorine is 1-3 mg/l (disinfection unit is shown on Fig. 3.1.).

Disinfected water is pumped to the buffer tank V 1 in the building from where it is transported further on to the consumers (see Simplified Process Flow Diagram on Fig. 3.3.).

- The pump P 1 and P 2 capacity is 4 l/sec

- The buffer tank V 1 volume is 5 cu m

Approx. 100 cu m of this water per diem is used for the following purposes:

- washing cola bottles and feeding the steam boilers. Before using it water is softened in the ion exchange columns (approx. 75 cu m/day)

- production of cola drinks

  Prior to the use, water is treated only physically on sand and active carbon filters, although some facilities for chemical treatment are installed but are not in use because the dosing system has broken down and there are no chemicals (approx. 20 cu m/shift).

- sanitary needs 5-7 cu m/day

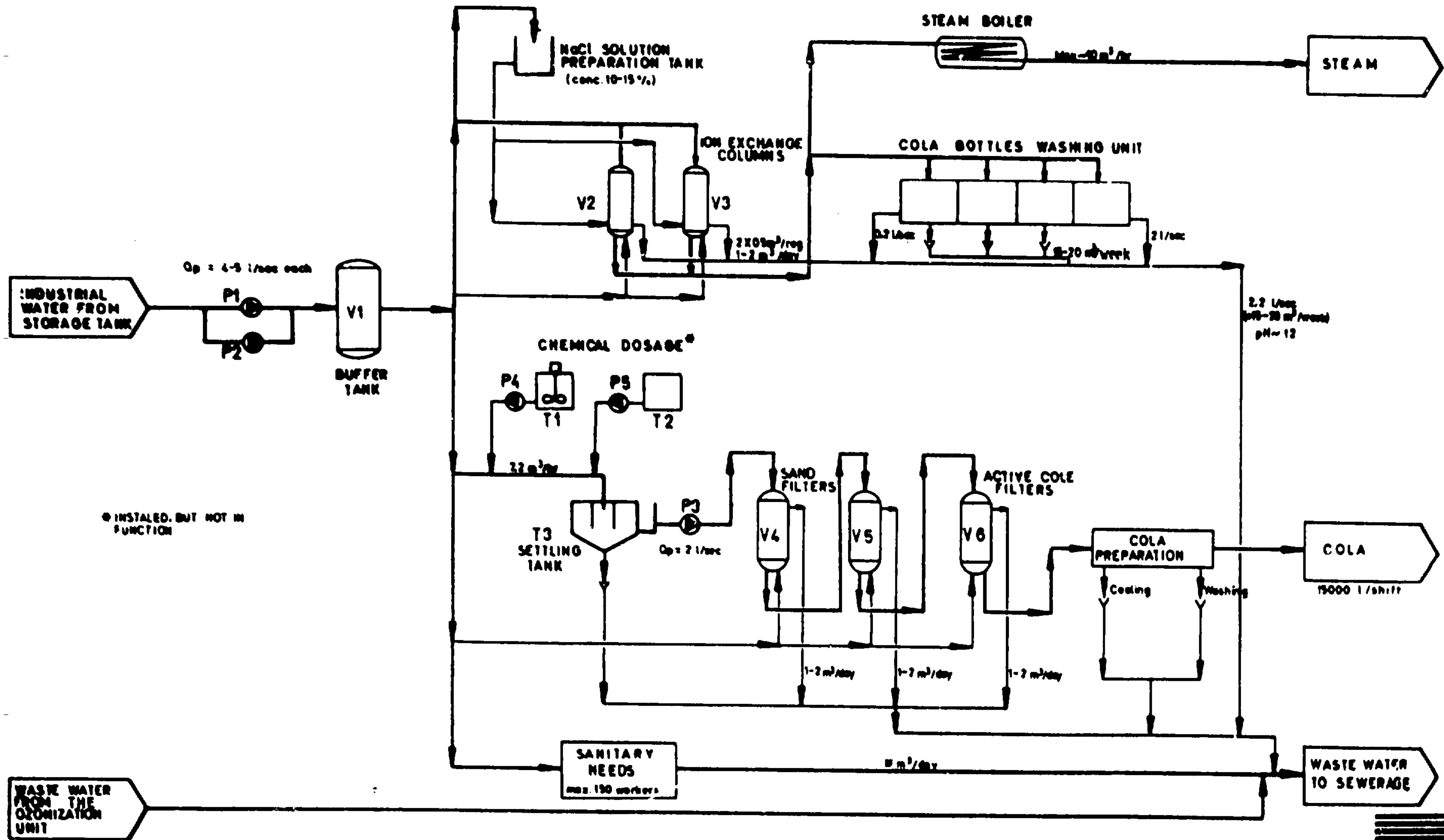


FIG. 3.3. SIMPLIFIED PROCESS FLOW DIAGRAM OF INDUSTRIAL WATER TREATMENT AND DISTRIBUTION
Drekish Water Factory

SOURCE / SUBSTANCE	MINERAL WATER ON WELL	MINERAL WATER PRODUCT	INDUSTRIAL WATER BEFORE TREATMENT	INDUSTRIAL WATER AFTER TREATMENT
Turbidity, NTU	0.5 – 2.6		0.5 – 25	0.3 – 5
Conductivity, µmhos/cm	200 – 260	200 – 250	300 – 400	330 – 340
pH-value	7 – 8	7 – 8	7.5 – 8.1	7.7 – 8.6
Total Hardness, °Fr	9 – 11	9 – 11	19 – 21	17 – 18
Ca-Hardness, °Fr	6 – 7		14 – 15	12 – 14
Mg-Hardness, °Fr	3 – 4		5 – 6	4 – 5
TAC, °Fr	9 – 11	9 – 11	17 – 19	17 – 19
CO_2 free, °Fr	20 – 60		24 – 36	4 – 6
$KMnO_4$ consumpt., mg/l		0.1 – 0.2		
Residue 105 °C, mg/l	130 – 140		200 – 230	160 – 210
Ca, mg/l	24 – 30	25 – 28	56 – 60	50
Mg, mg/l	6 – 9	7 – 9	10 – 16	13 – 14
HCO_3, mg/l	110 – 130	110 – 130	210 – 230	210 – 230
Cl, mg/l	12 – 16	10 – 15	1 – 2.5	17 – 18
Total microorganismus per 100 ml	5 – 75	∅	∅	∅
Coliforms per 100 ml	0 – 20	∅	∅	∅
Echerichia coli per 100ml	0 – 1	∅	∅	∅

3.2. THE ION EXCHANGE TREATMENT UNIT

(See Simplified Process Flow Diagram on Fig. 3.3.)

As it has been already explained, the water used for feeding the steam boiler and washing cola bottles must be softened by the ion exchange treatment.

This line consists of two neutral ion exchange columns, the working column and the stand by column. They are 1550 mm high and 600 mm in diameter. The volume of the column is approx. 440 l, and resin volume is approx. 200 l/column. NaCl solution is used to regenerate the resin. The solution is prepared in the tank of the following dimensions: 0 (diameter) = 950 mm, total height 1000 mm. During the preparation the tank is filled up to 700 mm, measured from the bottom. It means that the netto volume is about 500 l.

Resin is regenerated once in a shift, (which means once a day in winter and twice a day in summer) with approcx. 0,5 cu m of NaCl solution and washed with approx. 0,5 cu m of water. NaCl solution is prepared by dissolving 25 kg of salt in about 500 l of water (5 % solution).

Most of the softened water is used for cola bottles washing (about 65 cu m/day and twice as much in summer) while the rest is used for feeding the steam boiler. Two steam boilers have been installed, each having the capacity of 10 t of steam per hour. Only one boiler is in use while the other is stand-by.

3.3. WATER TREATMENT FOR COLA PRODUCTION

(See Simplified Process Flow Diagram on Fig. 3.3.)

An installed line for water treatment in cola production consists of:

- 2 vessels for preparation of chemicals (not used)
- 2 dosing pumps (not used)
- settling tank: netto volume about 7,5 cu m, and surface area 4,8 sq m
- 2 pressure sand filters, (O=1,2 and 1,0 m, H=1,5 m)
- active carbon filter (O = 1,0 m, H = 1,75 m)

Since water has not been treated chemically (no chemicals have been applied), the water it is only through sand filters and then it is filtered through an active carbon filter and that is when residual chlorine is removed. In winter the absence of chemical treatment causes the problem of suspended substances in purified water.

4. WASTE WATER FLOWS AND CHARACTERISTICS

4.1. GENERAL DESCRIPTION

The whole factory is situated on the area of 9700 sq m. All the production processes, administration, storages and auxiliary processes are settled in one building of the 4400 sq m area. The rest are paved manipulation areas.

All the effluents from the factory are collected by a combined sewerage system whose final recipient is a nearby small river.

The main sources of wastewater are shown on Water Treatment and Distribution Flow Diagrams (Fig. 3.1. & 3.3.).

The drainage system of effluents and their quantities are shown on the Block Flow Diagram (Fig. 3.4.).

4.2. EFFLUENT QUALITIES AND QUANTITIES

During our visit to the site we sampled all the effluents and organized laboratory analyses, but unfortunately we have not received the results yet. Anyhow, in Table 3.2. we shall try to summarize the main characteristics on the basis of our investigation (analysis during second Mission) and experience.

It is obvious that the effluents from the bottle washer present the main source of pollution. They consist of constant rinsing effluents and concentrated baths which are discharged periodically. Both of them are highly alkaline and contain large amounts of susppended solids resulting from strows, paper, cigarette butts etc. This foreign matter, plus leftover drink in bottles, is the major cause of a high BOD concentration.

Other process effluents are intermittent, and are not considered major sources of BOD and susp. solids. Naturally, sanitary wastes cannot be neglected.

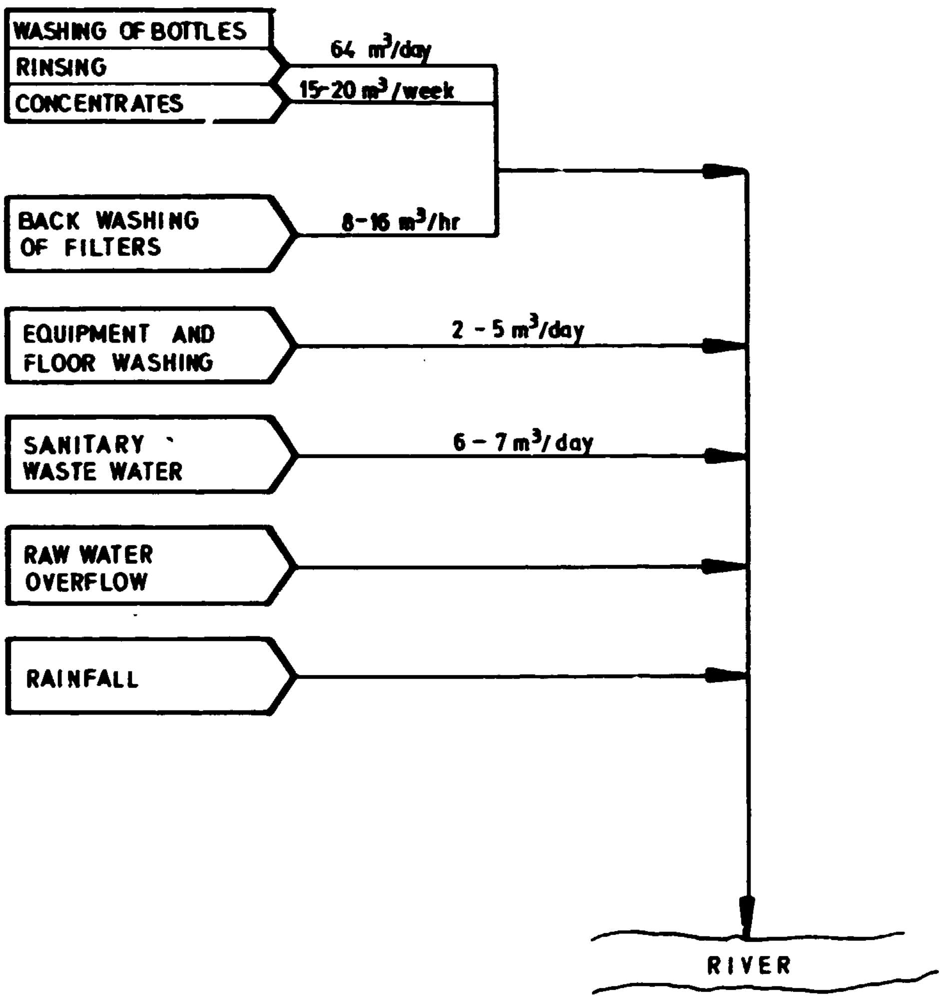


FIG. 3.4. BLOCK FLOW DIAGRAM OF THE DRAINAGE SYSTEM

Drekish Water Factory

TABLE 3.2.: CHARACTERISTICS OF THE EFFLUENTS FROM THE DREKISH-MINERAL WATER FACTORY

SOURCE	QUANTITY m3/d	max.l/s	pH	SUSPENDED SOLIDS, mg/l	BOD5 mg O2/l
BOTTLE RINSING	64	2,2	12-13	200-300	1000-1200
WASHING CONCENTRATES	*15-20	8-10	14	500-800	1000-1300
FILTER WASHINGS	**8-16	5	7-8	500-800	-
OTHER WASHING	2-5	2	7-8	200-300	400-500
SANITARY EFFLUENTS	6-7	2	7-8	200-300	330-450
TOTAL DRY WEATHER EFFLUENTS	82-112	12	10-11	200-300	400-900
RAINFALL		128***			

* once a week
** once a day
*** max. 10 min. period

5. WATER SUPPLY AND TREATMENT RECOMMENDATIONS

5.1. GENERAL OBSERVATIONS

1. The raw water inflow into the industrial raw water storage tank has not been controlled and there is a surplus of water which is mostly wasted.

2. The raw water surplus is disinfected quite unnecessarily, because it is wasted away right after the disinfection.

3. As it has been already said, there is a unit in the factory which disinfects raw industrial water with NaOCl solution.

   Dosing of the 10-12 % NaOCl solution is not controlled, because there is not any signal switch which would be turned on/off depending upon the NaOCl solution level in the dosing tank. It is very important considering the dislocation of the water disinfection unit in relation to the site of the factory. The automatic measure of the residual water chlorine does not exist, either.

4. A problem of slight turbidity in winter months (rainy period) is present at cola water after the treatment.

5. Before the ion exchangers there is no treatment of water due to the fine suspend solids elimination.

6. There is no ozone monitoring equipment on the mineral water treatment line.

5.2. INDUSTRIAL WATER SUPPLY AND DISINFECTION

The existing system of industrial raw water supply has been described in article 3.1. in this Part and graphically presented in Fig. 3.2.

The basic objections to that way of water supply and disinfection are as follows:

1. Unnecessary waste of electric power for subsequent pumping of water that will later through overflow in tank T 2 be thrown away as waste water.

2. Unnecessary disinfection of water, thrown away later on.

3. Nonexistence of automatic dosing of NaOCl solution depending upon the residual chlorine in disinfected water.

5.2.1. Desription of the Recommended Solution

System for raw industrial water supply and disinfection should be modified and made up in the following items:

1. To avoid unnecessary waste of electric power for prepumping of surplus water, automatic switch on/off should be installed on the pump in the pump station PS 1 (level regulation LSHL 1; see Fig 3.5.).

2. A control electro-magnetic valve LCV 1 should be built in at the very beginning of the pipe for the inflow of industrial water into the tank T 2. The valve reacts on the water level in the tank T 2 (regulation LSHL 2).
   (Fig 3.5. and 3.6.)

3. The automatic unit for dosing the NaOCl solution should be built in (Fig. 3.6.). In that way dosing of the NaOCl depends upon the water level in the tank T 2 (dosage pump P 1 is turned on/off by an imput from the LSHL 2 regulation).
   On the other hand an automatic analyser and controler of the residual chlorine should be built in (AIC 1 - Cl) with the alarm system of high and low chlorine contents (AAHL - 1 - Cl 2). The automatic regulation is used to increase or decrease of NaOCl solution quantity, depending upon the wanted concentration of residual chlorine in the industrial water system.

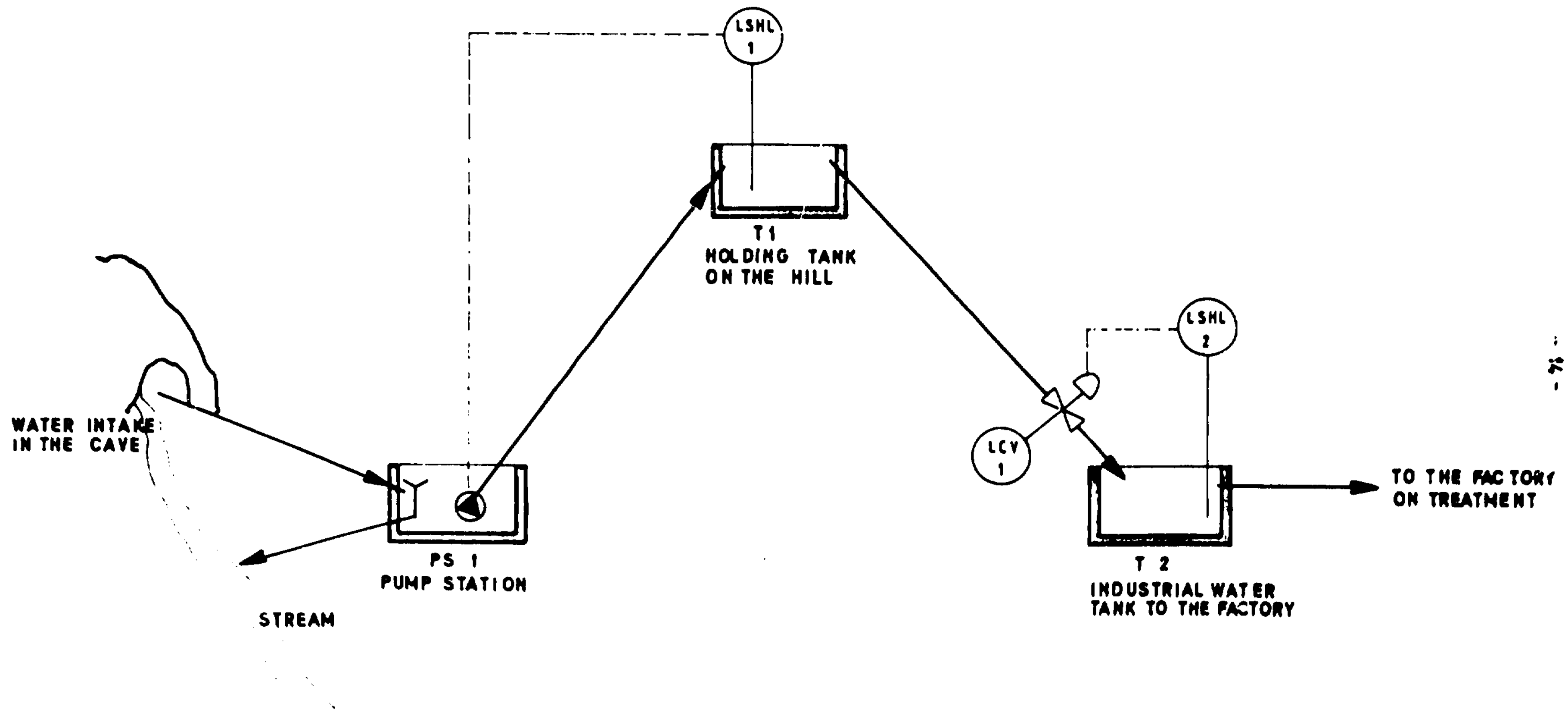


FIG. 3.5. ILLUSTRATION OF RECOMMENDED AUTOMATION OF WATER SUPPLY SYSTEM

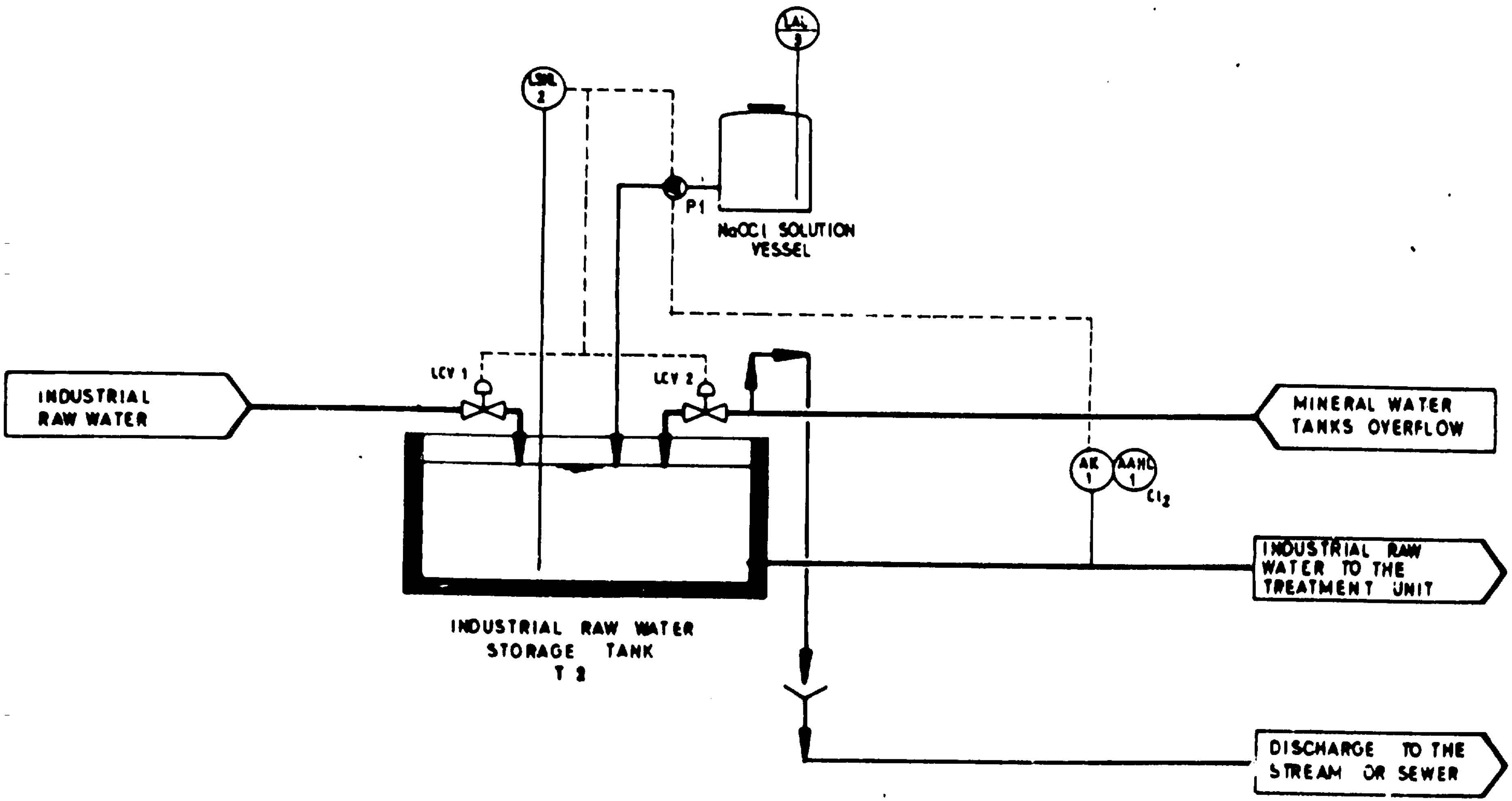


FIG. 3.6. INDUSTRIAL WATER DISINFECTION UNIT (recommendation) - CASE 1
Drekish Water Factory

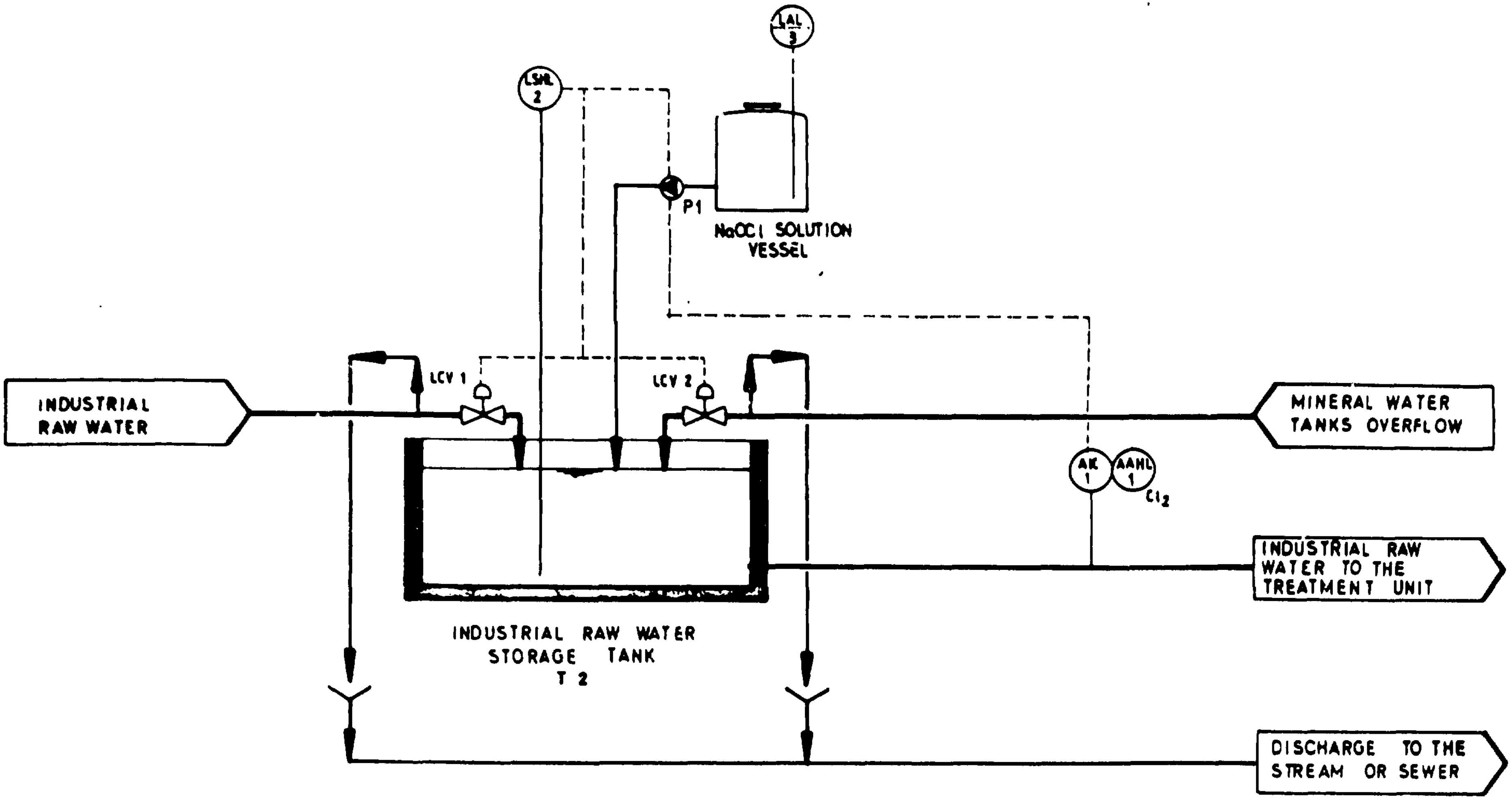


FIG. 3.7. INDUSTRIAL WATER DISINFECTION UNIT (recommendation) – CASE 2
Drekish Water Factory

4. To avoid unnecessary disinfection of surplus water, control electromagnetic valves should be built in (LCV 1 & 2) on the supply pipes and bypass of surplus waters (Fig. 3.7.).

Fig. 3.6. (Case 1) shows the water supply and systems for automatic dosing of chlorine and water disinfection in case that the modification of water supply described in articles 1 & 2 of this chapter are adopted.

Fig. 3.7. (Case 2) shows again the water supply and systems for automatic dosing of chlorine and water disinfection, but in case that the suggested modification is not accepted. In this case only the unnecessary chlorination of surplus water is avoided.

5.2.2. Equipment Specification

- Electromagnetic Valves — No 100

  2 pcs

- Level Control Units — (LSHL 1 & 2)

  2 sets

- Dosage Unit for NaOCl Solution

  It consists of the following main components:

  plastic vessel: 100 l
  mixer for manual use,
  dosage pump,
  low level signalling

  1 set

- Automatic analyser of residual chlorine with printer and alarm system

  1 set

5.3. COLA WATER TREATMENT LINE

5.3.1. Checking of Equipment Capacity

SETTLING TANK S-01 (Fig. 3.8.)

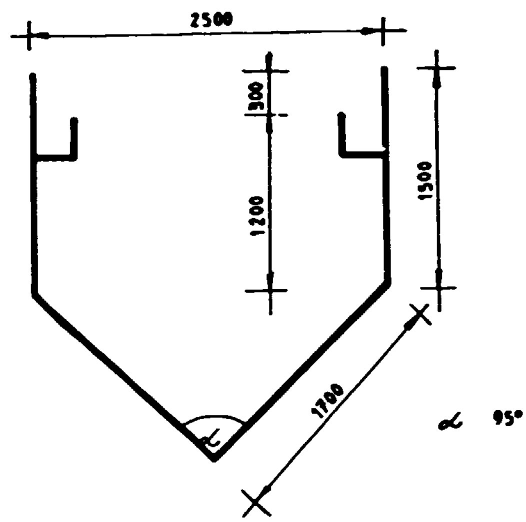


FIG. 3.8.

- Area, A = 4,9 sq m
- Volume of the cylindric part (to the overflow),

  V1 = 5,9 cu m
- Volume of the conical part, V2 = 1,5 cu m
- Total useful volume, V1 + V2 = 7,4 cu m
- Water flow, Q = 7,2 cu m/hr (measured in situ)
- Retention time, $R = \frac{7,4}{7,2} = 1$ hr

  Retention time is usually 1-1,5 hr, which means that the settling tank is in order.

- Specific surface loading:

$$S = \frac{7,2}{4,9} = 1,5 \text{ cu m/sq m hr}$$

Usually it should be: 1,7-2,1 cu m/sq m hr

PRESSURE SAND FILTERS (SF-1, SF-2)

	SF-1	SF-2
- Diameter, D	1,2 m	1,0 m
- Height, H	1,5 m	1,5 m
- Sand column height, h	1,0 m	1,0 m
- Cross section area,A,A1	1,1 sq m	0,8 sq m

The filtration velocity in pressure sand filters can be max. 4 m/hr, with the sand columns height of about 1,0 m. Under assumptior that only one filter is in operation, while the other is stand-by, the following velocity values can be obtained:

For SF-1: $V = \frac{7,2}{1,1} = 6,5$ m/hr

For SF-2: $V = \frac{7,2}{0,8} = 9,0$ m/hr

These filtration velocity values are too high and they correspond to the sand filters having the sand columns 1,5 to 1,8 m high.

Under assumption that both filters are in operation at the same time, the filtration velocity will be:

$$V = \frac{Q}{A + A1} = \frac{7,2}{1,1 + 0,8} = 3,8 \text{ m/hr}$$

This value is obtained according to the above mentioned criteria.

5.3.2. Desription of the Recommended Solution

(See Process Flow Diagram on Fig. 3.9.)

Surface waters generally contain suspended and colloidal solids from land erosion, decaying vegetation, microorganisms, and colour-producing compounds. Coarser materials such as sand and silt can be eliminated to a considerable extent by plain sedimentation, but finer particles must be chemically coagulated to produce larger flocs which are removable in subsequent settling and filtration.

Coagulation and flocculation are sensitive to many variables, for instance the nature of the turbidity-producing substances, the type and dosage of coagulant, pH of water etc. Of many variables that can be controlled in plant operation. pH adjustment appears to be the most important.

The commonly used metal coagulants in water treatment are: (1) those based on aluminium, such as aluminium sulphate, sodium aluminate, potash alum and ammonia alum: and (2) those based on iron, such as ferric sulphate, ferrous sulphate, chlorinated copper, and ferric chloride.

By partial checking of the installed equipment it has been found out that its capacity is in order to perform psychical and chemical treatment.

Al-sulphate in the form of a 2,5 w/w % $Al_2(SO_4)_3 \times 18 H_2O$ solution would be used as a coagulant. The Al-sulphate quantity used for drinking water treatment varies upon the quantities of present suspended substances in raw water. The exact quantity can be determined by lab jar-tests.

Difficulties with coagulation often occur because of slow-settling precipitates or fragile flocs that are easily fragmented under hydraulic forces in basins and sand filters. Coagulant aids benefit flocculation by improving settling and bloc toughness. The most widely used materials are polyelectrolytes, activated silica, adsorbent-weighting agents and oxidants.

Synthetic polymers are a long-chain, high-molecularmass, organic chemicals commercially available under a wide variety of trade names, and are often used with metal coagulants to provide bridging between colloids to develop larger and tougher floc growth.

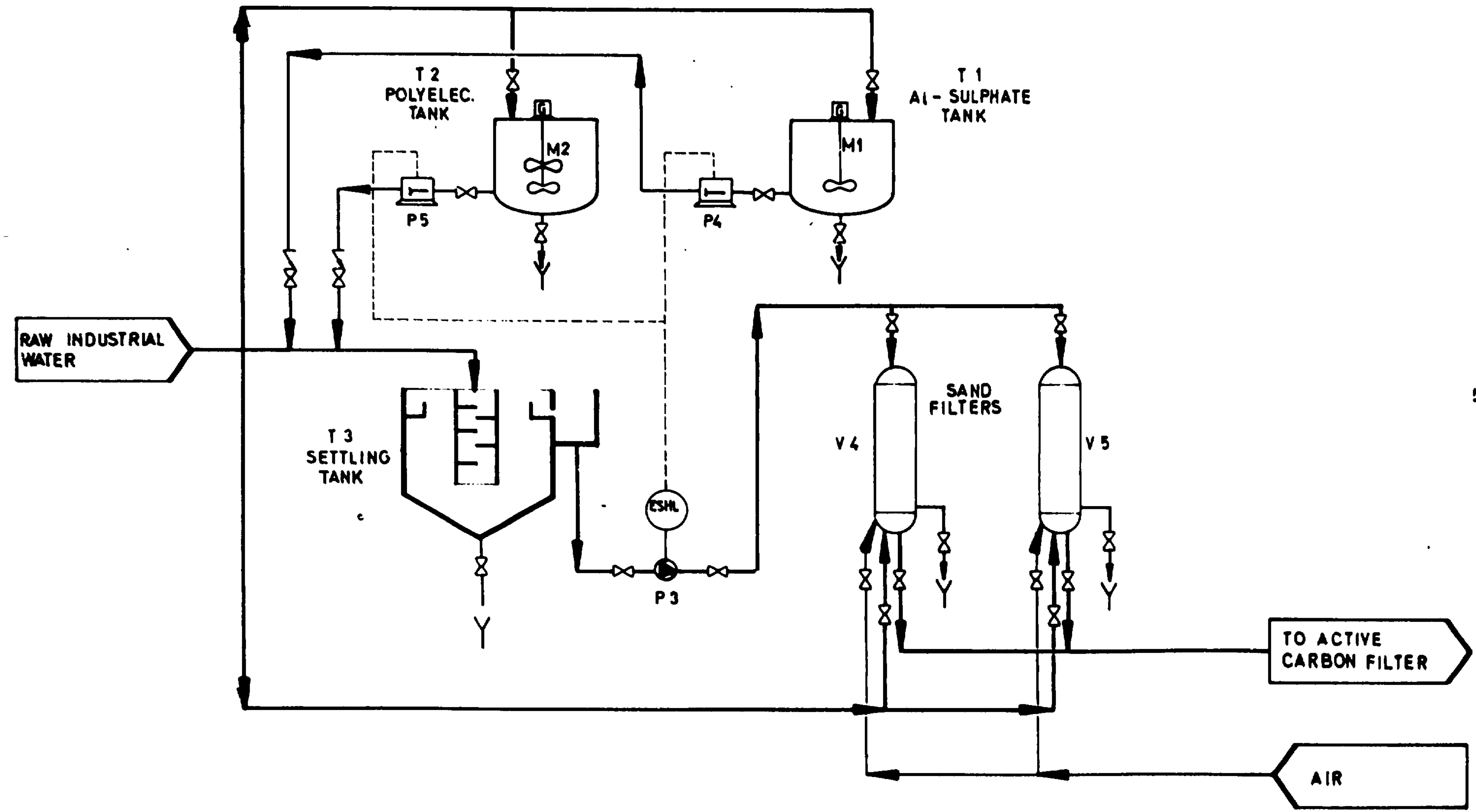


FIG. 3.9. INDUSTRIAL WATER TREATMENT (chemical part – recommendation)
Drekish Water Factory

This chemicals have been manufactured by several firms, the best known being NALCO, CYANAMID, STOCKHAUSEN, GIULINI, R DONA, BETZ etc.

The dosing quantity of polyelectrolite is generally in order of 0,1-1,0 mg/l while the dosing solution concentration is 0,02 to 0,04 %.

During our second visit to Syria we planned to make some lab tests to determine the best dosage concentrations of coagulants and flocculants for turbidity elimination in the industrial raw water (the part of water used for cola production).

During spring, summer and fall there are no problems with water turbidity.
As we were there in May we had to simulate turbidity in a water sample to demontrate the possibilities and ways of water treatment. Using soil we reached the turbidity of approx. 25-30 NTU. These are the highest values that can apper in winter months.

The more detailed description of the tests and instructions for application of the obtained results in water treatment are given later.

NOTE: PE SUPPLYERS ADRESSES:

STOCKHAUSEN GMBH
Bakerpfad 25
Postfach 570
D-4159 KREFELD 1
W. GERMANY

NALCO - Austria
Scheydgasse 34-36
A-1210 VIENNA
AUSTRIA

CYANAMID- Germany
Pfaffenriederstrasse 7
D-8190 WOLFRATSHAUSEN
W. GERMANY

GIULINI
Postfach 123
6700 LUDEIGSHAFEN/Rhein
W. GERMANY

R. DONA
Via Ampere 47
20131 MILANO
ITALY

BETZ
Vivenotgasse 30/4
1120 WIEN
AUSTRIA

According to lab tests made on a simulated water sample the maximum dosage quantities up to 75 mg/l of Al-sulphate and 1 mg/l pf polyelectrolyte werw reached.

NOTE: Quantitative analyses of residual aluminiun in the treated sample were not possible in the Drekish laboratory.

Water quantity 30 cu m/day

(7,2 cu m/hr)

- Required Al-sulphate x 18 H20

75 mg/l = 0,075 kg/cu m

0,075 x 30 = 2,25 kg/day

- Required 5 % Al-sulphate solution:

$$\frac{2,25}{0,05} = 45 \text{ l/day}$$

- Solution dosage in one hour period:

$$\frac{0,075}{0,05} \times 7,2 = \text{cca } 11 \text{ l/hr}$$

The installed dosing pump for the coagulant solution (P-3)has the capacity of 0-26 l/hr, which means that it can be freely used.

- required PE

max. 1 mg/l = 1 g/cu m

1 x 30 cu m/day = 30 g PE/day

- 0,025 w/w % solution required:

$$\frac{0,03}{0,00025} = 120 \text{ l/day}$$

- solution dosage in one hour period:

$$\frac{0,001}{0,00025} \times 7,2 = \text{cca } 29 \text{ l/hr}$$

The installed pump for flocculant dosing (P-4) has the capacity of 0-70 l/hr, which is satisfactory.

Both dosing pumps should be installed to operate automatically, in connection with the pumps that pump water from settling tanks into the sand filters.

5.3.3. Equipment Specification

See Fig. 3.9.

Almost all the necessary equipment has been installed. The only thing that misses is the mixer in the container for polyelectrolite solution preparation.

- Mixer M 2

  Type: prop-driven (2 propellers)
  Power of the electric motor: 0,55 kW
  Propeller speed: 200 rpm

  1 pc

- Container for chemicals solution should be cleaned and covered by the epoxide coat.

5.4. ION EXCHANGE TREATMENT LINE

The most important rule for softening on ion exchangers is:

- the inlet has to be physically clean and contain no iron.

As there is an obvious appearance of periodical slight turbidity in raw industrial water, we think that it has negative influences on ion exchangers. Operation on the ion exchanger is apparently blocked by suspended substances, and the useful capacity of the ionic resin is decreased.

In Fig. 3.10. the basic operation of the industrial water treatment has been given. But the given concept is impossible to be carried out with the existing equipment. The capacity of the chemical treatment line and sand filters should be double what it is now.

5.5. MINERAL WATER SURPLUS

Mineral water is constantly pumped from the well, the quantity reaching 100 cu m/day. The whole quantity is used only during the summer. When approx. 90 cu m/day of mineral water is being produced.

In winter months the demand is half as small and the production is organised in one shift only with 45 000 l of water per diem. In this period water is thrown away. As this water is mechanically clean and disinfected (it was filtered by sand filters and ozonizated) we are of the opinion that water shouldn't be thrown away. It can very easily be used for cola production.

5.5.1. Desription

See Fig. 3.11.

A pipe with a valve should be added to the pipe-line behind the pump. It leads to the sedimentation basin during the cola water production. In this way water will flow through the filter with activated charcoal where possible residual ozone will be removed from water.

In the same way the usage of industrial water for cola production is avoided during winter months (when water turbidity is possible).

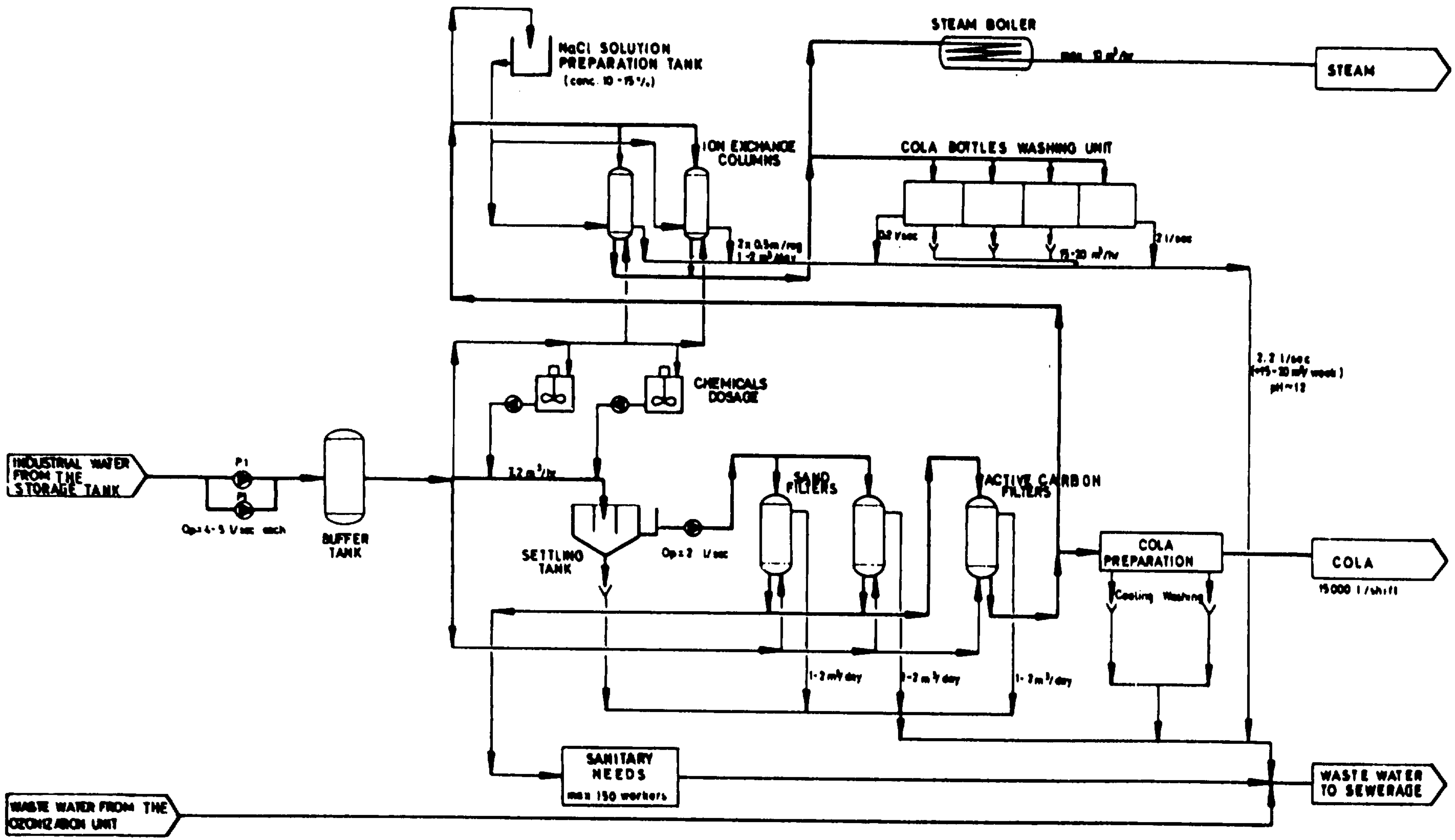


FIG. 3.10. SIMPLIFIED PROCESS FLOW DIAGRAM OF INDUSTRIAL WATER TREATMENT AND DISTRIBUTION (recommendation) Drekish Water Factory

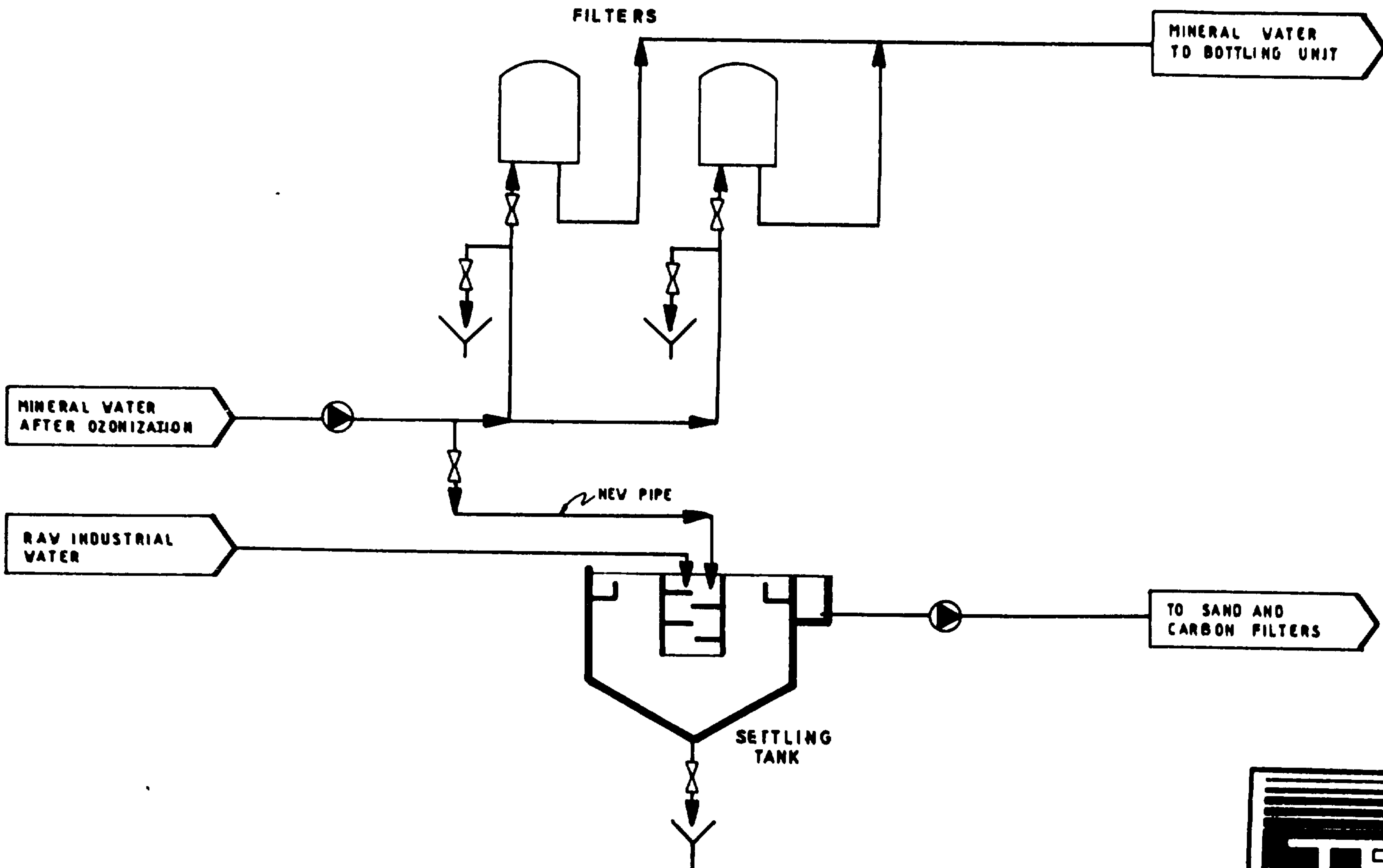


FIG. 3.11. FLOW DIAGRAM - CONECTION PIPE FOR USING SURPLUS MINERAL WATER IN COLA PRODUCTION

5.6. BILL OF QUANTITIES AND COST ESTIMATIONS

5.6.1. Industrial Water Disinfection and Supply

5.6.1.1. Equipment Cost

- Control cable between tank (T 1) and pumps (PS 1)

2500 m	7.500 USD

- Solenoid valve LCV 1

1 pc	150 USD

- Level Switches (LSHL 1 and LSHL 2)

2 sets	500 USD

- NaOCl solution dosing equipment accessories Consisting of: one dosing pump (P 1), pump suction line system, back pressure valve, PVC chemical tank (T 1) signal horn for level alarm (LAL 2) and signal lamp-alarm, manual stirrer, measurment and recording of residual chlorine (AIC 1-Cl2)

1 set	4.250 USD
TOTAL (5.6.1.1.):	12.400 USD

5.6.1.2. Civil Works

- Excavation, control cable installation and filling.

L = 2500 m

450 m3 x 50 SP/m3 = 22.500 SP

eq 1.023 USD (1 USD = 22 SP)

5.6.2. Chemical Treatment of Cole-water

- Stirrer for PE-solution preparation

Type:	prop-driven (2 propellers)
Elec.motor power:	0,55 kW
Propeller speed:	200 rpm

1 pc	1.500 USD

RECAPITULATION

Equipment: 13.900 USD

Civil works: 1.023 USD

5.7. RUNNING COSTS

Basically, running costs (CR) consist of the following:

- maintenance costs (CM)
- energy costs (CE)
- costs for Chemicals (CC)
- labour costs (CL)
- depreciation costs (charges) (CA)

Maintenance costs (CM) are usually about 1,5 % of capital costs.

Energy costs (CE) consist of electric power and steam costs. Labour costs (CL) are applied according to the number of employed as well as the costs that are to be ensured for each employee.

Depreciation costs (CA) are applied with 6,7 % per annum of capital costs (based on the 15 year period exploitation).

NOTE: Running costs are computed only through newly suggested equipment. Working days per annum 285.

Maintenance Costs (CM)

CM = 14.923 x 0,01 = 1.292 USD

Chemical Consumptions (CC)

Al-sulphate x 18 H_2O: 2,25 kg/day

2,25 kg/day x 285 day/year = 641 kg/year

Cationic PE consumption 0,03 kg/day

0,03 kg/day x 285 day/year = 8,6 kg/year

NaOCl solution (13 % available Cl2): 3 kg/day

3 kg/day x 285 day/year = 1.083 kg/year

Energy Consumption (CE)

- Pump NaOCl:

  0,016 kW x 15 hr/day x 285 day/year = 257 kW hr/year

- Pump Al-sulphate:

  0,55 kW x 15 hr/day x 285 day/year = 2351 kW hr/year

- Pump PE:

  0,55 kW x 15 hr/day x 285 day/year = 2351 kW hr/year

- Stirrer Al-sulphate:

  0,55 kW x 1 hr/week x 52 weeks/year = 29 kW hr/year

- Stirrer PE:

  0,55 kW x 2 hr/day x 285 day/year = 314 kW hr/day

  TOTAL: 5302 kW hr/year

Labour Cost (CL)

- Approximately 3 man-hours/day

  3 x 285 days/year = 855 man-hours/year

Depreciation Costs (CA)

CA = 13.900 USD x 0,067 = 931 USD/year

5.8. LAB INVESTIGATION WORKS

5.8.1. General

As there were no traces of turbidity in industrial water during our visit to the Drekish factory (summer period), turbidity was simulated by adding mud into water until the turbidity rate reached the value of 25-30 NTU. By experience, this is the highest value to be expected.

Two series of jar-tests were laboratory performed. In the first series water was treated by different concentrations of Al-sulphate and cationic polyelectrolyte. In the second series of tests, lime was added as well.

Unfortunately, the Drekish laboratory is not equipped for analyses of surplus aluminium in chemichally treated water samples.

5.8.2. Results of the first series of tests

Preparation of the Al-sulphate solution x 18 H20

Approx. 2,5 w/w % solution of Al2(SO4)3 x 18 H20 should be prepared.

10 g of Al-sulphate should be dissolved in 400 ml of water.

$$\frac{10 \times 100}{400} = 2,5 \text{ w/w } \%$$

1 ml of solution contains 10 000/400 = 25 mg of Al-sulphate.

Preparation of the polyelectrolyte solution

Approx. 0,025 w/w % polyelectrolyte solution should be prepared.

100 mg of PE in powder (0,1 g) should be dissolved in 400 ml of water.

$$\frac{0,1 \times 100}{400} = 0,025 \text{ w/w } \%$$

1 ml of the solution contains 100/400 = 0,25 mg PE

Samples of 500 ml of water were tested.

Al-sulphate solution was dosed in the following concentrations: 10, 25, 50 and 75 mg/l.

To reach those values of Al-sulphate, the following volumes of 2,5-percent of Al-sulphate solution werw added into the 500 ml water samples:

- for 10 mg/l:

  1/5 ml (0,2 ml) contains 5 mg of Al-sulphate -

$$\frac{5 \text{ mg}}{0,5 \text{ l}} = 10 \text{ mg/l}$$

- for 25 mg/l:

  1/2 ml (0,5 ml) contains 25/2 =12,5 mg of Al-sulphate

$$\frac{12,5 \text{ mg}}{0,5 \text{ l}} = 25 \text{ mg/l}$$

- for 50 mg/l: 1 ml
- for 75 mg/l: 1,5 ml

Out of four tests with the concentrations mentioned above, the best result was reached with the concentration of 75 mg/l od Al-sulphate.

Cationic polyelectrolyte in the concentrations of 0,5 and 1,0 mg/l was used as a flocculant. To reach those values of PE in the 500 ml sample, the following volumes of 0,025-percent pE solutin were added:

- for 0,5 mg/l:

  0,25 mg/500 ml equivalent to 0,5 mg/l

It means that 2 ml of PE solution should be added (1 ml contains 0,25 mg of PE).

- for 1,0 mg/l

4 ml of PE solution should be added.

A good result was noticed at the concentration of 0,5 mg/l of PE.

Conclusion:

Turbidity in the prepared samples could be removed with dosage concentrations of 50-75 mg/l of Al-sulphate and 0,5 mg/l of cationic polyelectrolyte.

After 30 minutes sedimentation, turbidity in clear water was 4,4 NTU. Rare flocs are easy to eliminate by sand filters.

The pH value of water samples before the test was 8,5 while it was 8,0 following the test. The total hardness decreased inconspicuosly (from 22 to 21 o fH).

5.8.3. Results of the second series of tests

500 ml samples of water were used for jar-tests. The pH-value of water is 8,5 the total hardness is 22 o fH and turbidity is 27 NTU. Al-sulphate solution (2,5 w/w %) has been dosed to the concentration of 50 mg/l (1 ml for 500 ml of samples).

Cationic polyelectrolyte solution was dosed to the concentration up to 0,5 mg/l (2 ml 0,025 w/w % solution to 500 ml of sample).

Dosing of lime hydrate varies from 100, 50 to 200 mg/l (50, 75 and 100 mg of lime added in 500 ml of sample). Those concentrations were selected because they didn't require subsequent adjustment of pH values following the chemical reaction, and pH values are in tolerated range for the Al-sulphate action.

Glass 1

500 ml of water sample

50 mg/l of Al-sulphate

100 mg/l of lime
0,5 mg/l of PE
5 minutes mixing
60 minutes sedimentation

The following was measured after the chemical reaction and the period of standing.

pH	6,8
turbidity	6 NTU
total hardness	14,0 o fH

Glass 2

All the quantities were the same as in glass 1, except for lime (150 mg/l were added).

Measured values:

pH	7,6
turbidity	5 NTU
total hardness	12,3 o fH

Glass 3

All the quantities unchanged, only 200 mg/l of lime was added.

Measures valued:

pH	9,0
turbidity	5 NTU
total hardness	10,0 o fH

Conclusion:

Satisfying results were obtained in all the three cases. In our opinion the dosage concentration of lime of approx. 150 mg/l is best. The reasons are as follows:

1. The pH value of water reached the value of approx. 7,6 following the test and there is no need for subsequent correction of that value.

2. The hardness of water decreased for approx. 45 % and it is approx. 12 o fH.

3. The sediment is weighty and easy to eliminate by gravitation (sedimentation). The low rate of turbidity is easy to eliminate by sand filters.

5.8.4. Instructions for use of the chemical treatment line of industrial water

Preparation of Al-sulphate solution

The results of our laboratory tests pointed to the fact that approx. 75 mg/l of Al-sulphate should be added in the water of simulated turbidity of 25-30 NTU. In the following text we shall explain the way of preparing the solution and needed quantities of approx. 2,5 w/w % of the Al-sulphate solution x 18 H2O.

The following table presents the needed quantities of water and dry substance of Al-sulphate x 18 H2O needed for approx. 2,5 w/w % solution:

l water	kg Al-sulphate x 18 H2O
50	5,5
75	8,4
100	11,0
200	22,0
300	33,0
500	55,0

The maximum flow of water diem day that should be treated is 30 cu m/day. The flow per hour is 7,2 cu m/hr.

A daily demand of Al-sulphate (dry substance) is:

75 mg/l eq. 75 g/cu m eq. 0,075 kg/cu m

0,075 x 30 = 2,25 kg/day

In 2,5 w/w % solution it is:

2,25/0,05 = 45 l/day

The dosage quantity of 5 w/w % solution in the period of one hour is:

0,075/0,05 x 7,2 = approx. 11 l/hr

It is obvious then that the dosage pump of the Al-sulphate solution should be calibrated to that flow by means of a stop-watch and graduated cilinder.

The Al-sulphate solution can be prepared several days in advance, depending upon the volume of the vessel at hand. As the vessel for preparation of the Al-sulphate has approx. 0,5 cu m of the useful volume, it is possible to prepare almost ten days quantity of the solution.

To prepare the solution the wanted quantity of water is poured into the vessel, the mixer is turned on and an adequate quantity of dry Al-sulphate is added gradually. When the Al-sulphate is dissolved, the mixer is turned off. The whole process of dissolving lasts 15 to 20 minutes.

Preparation of the polyelectrolyte solution

The cationic polyelectrolyte solution can be prepared only for immediate use (the solution loses its active components after 24 hours).

The needed daily quantity of 0,025 w/w % cationic polyelectrolyte solution is:

Flow of water:	30 cu m
Max. flow per hour:	7,3 cu m/hr
Dosage quantity of PE:	1 mg/l (g/cu m)

1 g/cu m x 30 cu m/day = 30 g/day

In 0,025 w/w % solution:

0,03 kg/day/0,00025 = approx. 120 l/day

The dosage quantity for a period of one hour is:

0,001/0,00025 x 7,2 = approx. 29 l/hr

This flow of the PE solution should be calibrated on the dosage pump by means of a stop-watch and a graduated cylinder.

To prepare the solution, 120 l of water are poured into the vessel and the mixer is turned on. Polyelectrolyte in powder is added gradually. It must not be added all at once!

The process of dissolving lasts for about two hours. When polyelectrolyte has dissolved completely, the mixer should be turned off.

Description of work

1. The flow of chemicals solution should be calibrated to the wanted quantity on dosage pumps.

2. The dosage pumps for chemichals should be turned on in the same time when the flow of raw water into the sedimentation tank is turned on.

3. The dosage pumps should be turned to automatic work, if it exists.

4. Sludge drainage from the bottom of the sedimentation basin can be done periodically. The maximum daily quantity of sludge can be about 60 l (on the basis of measurements of laboratory treated water in Imhoff cone with turbidity of raw water reaching the value of 27 NTU and the sedimentation period of two hours). As the volume of the conical part of the sedimentation basin is 1500 l, sludge can be drained every ten days, quantities being about 500 to 600 l.

5. The dosage pumps are turned off automatically when pumps pumping water from sedimentation tank into the sand filters are turned off.

6. RECOMMANDATIONS FOR WASTEWATER TREATMENT AND DISPOSAL

6.1. GENERAL POSSIBILITIES

Comparing the characteristics of effluents (Tab: 3.2.) with the Standards from Chapter 2.2., it is obvious that they cannot be discharged into the municipal sewerage and certainly not into the river without treatment.

The main concern are a high pH-value and high concentrations of BOD and suspended solids.

Concentrations of BOD and suspended solids can be sufficiently decreased by biological treatment either on the municipal plant or on the one owned by the factory. But in any case process effluents have to be neutralized before biological treatment.

In the following chapter we shall describe the possibility of a complete treatment system on the factory site because a municipal one doesn´t exist. But if there is a chance for the erection of the municipal treatment system , hydraulic and BOD loads after neutralization have to be taken in consideration for its design and calculations. In fact, it is well known that in most cases it is more economical to take a financial part in a municipal system than to build a new treatment plant.

6.2. TECHNICAL DESCRIPTIONS AND CALCULATIONS

(See fig. 3.12.: Process Diagram of the Effluent Treatment)

All the process effluents will be discharged by gravity into a separate sewer and led through a manually cleaned bar rack (R-01) into the neutralization basin (T-02). The content of the basin will be mixed and automatically neutralised by the HCl solution.

Concentrated baths from the bottle-washer should be discharged into the buffer tank by the same sewer out of the working time (while other effluents are not present). From the buffer tank the concentrate will be continuously dosed by a moyno pump (P-01) into the neutralisation basin T-02 and treated together with other effluents.

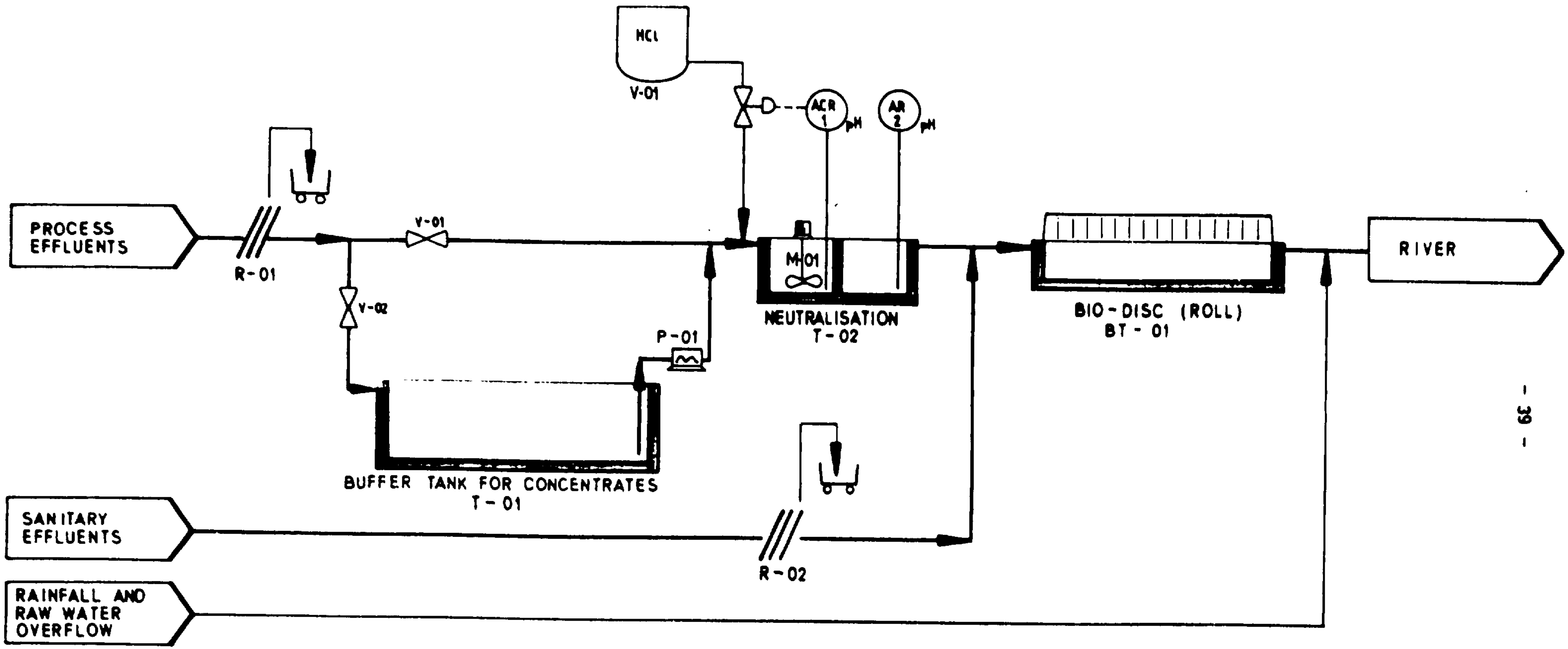


FIG. 3.12. PROCESS DIAGRAM OF THE EFFLUENT TREATMENT (recommendation)
Drekish Water Factory

Sanitary effluents will be discharged by a separate sewerage and after passing through a manually cleaned bar rack (R-02), mixed with neutralised effluents. The mixed effluents should be treated by a covered compact biological unit (BT-01) which is suitable for settling inside the populated or industrial (especially food-) area.

After the final treatment the effluent should be mixed with the raw water overflow and rainfall and discharged into the river.

Buffer Tank for Concentrates (T-01)

The concentrates will be discharged into a concrete tank by closing the sluice V-01 and opening the sluice V-02. From the tank, the concentrates will be continuously transported into the neutralisation tank by a dosing pump (P-01).

Concentrate quantity: 15-20 cu m/week
Lenght: 4,5m
Width: 2,0 m
Water depth: 2,2 m
Tank volume: 20 cu m

- Pump (P-01) capacity: Q = 1000 l/hr
  P = 1,4 bars
  N = 0,5 kW

Neutralisation

Automatic neutralisation will be performed in a concrete basin divaded in two parts by mixing wastewater with a 10 % HCl-solution in the first part. Dosing of the HCL-solution should be automatically regulated by feedforward pH-control.

- Neutralisation Basin (T-02)

  Volume: 5,49 cu m
  Lenght: 2,8 m
  Width: 1,4 m
  Water depth: 1,4 m

- Mixer (M-01)

  N = 0,7 kW
  RPM = 210
  L = 1700 mm
  0 = 450 mm

- HCl Holding Tank

  Volume: 5000 l (one week operation)
  0: 1400 mm
  H: 3450 mm

- Automatic HCl Dosing System:

  - pH meter
  - pH recorder
  - feedforward computer
  - electro-magnetic value

- End Control:

  - pH meter
  - pH recorder

THE BIOLOGICAL TREATMENT UNIT

Unit consists of:

- primary settling area
- bio-zone and
- secondary settling area

- The Primary Settling Area

  Waste water flows directly, by gravitational feed into the primary settlement area. No equalization basin is necessary as the rotary disc system smooths out the uneven inflow better than any other purification system.

  Floating debris is stopped by the sunken partition and the suspended particles settle evenly on the sump bottom.

- The Bio-Zone

  The partitions installed in the bio-zone prolong the contact of waste water with the active biomass formed on the surface of the plastic filling on the roll.

  The rotation of the roll ensures an efficient contact of the biological film both with the air and with nutrients.

The submersion into waste water (which supplies the bacterial mass with nutrients) alternates with resurfacing (which supplies it with oxygen needed for the aerobic decomposition, thus creating favourable conditions for a rapid formation of a stable, biologically active slime layer which adjusts easily to the varying load concentrations.

The thickness and structure of the biomass vary along the profiled plastic filling wound around the rotor shaft, ensuring a high level of purification and partial nitrification.

The perforated polyethylene filling is profiled to increase the active surface area and then wound onto the shaft. The contact of waste water with the air is further increased by dripping water droplets bursting on impact with the surface, improving the aeration.

Above the wound plastic filling the longitudinally slotted tubes are installed. They take air into waste water as they submerge and then release it during rotation. The resulting upward stream of air bubbles additionally encriches the bacterial mass with oxygen. The tubes then scoop waste water and upon the completion of the rotation spill it over the plastic filling for further mixing effects and interaction with the biological film.

Due to the drag caused by the passage through waste water, the surplus biomass flakes off the base layer and through the slots in the bio-zone construction settles into the primary settlement sump. This way the recycling of active sludge is ensured without a pump.

The unit thus provides service without any extra energy expenditure and without any need for constant supervision by qualified personnel.

- Secondary Settlement Area

The rest of the sediment collects in the sump of the socondary settlement area. To improve the quality of the effluent still further a set of parallel plates is installed ahead of the outlet overflow part at the angle of 45 o.

The upward flow successfully separates even the particles that resist sedimentation and in practice the effluent does not contain more than 10 mg/l of suspended particles.

Waste water treatment with such units produces less sludge than the other active sludge processes. Characteristicr'ly large slime floccules are formed and quickly settle in the secondary settlement sump, resulting in high working efficiency.

Sludge from the primary and secondary sumps does not have to be disposed of more often than two to three times a year. Further treatment is performed at the nearest larger communal sewage treatment plant or it is possible to deposit the sludge directly onto the agricultural land.

In comparison with other conventional active sludge biological systems, the described unit needs less energy and maintenance. The unit is esthetically shaped and covered, which prevents odour or aerosols emission, and makes it suitable for installation in populated and industrial areas.

- Hydraulic load: 82-112 cu m/day
  Q max = 10 l/sec

- Organic load: 35-45 kg BOD5/day
  l = 400-500 mg/l

Biological unit:

Lenght: 15,6 m
Width: 4,2 m
Height: 5,0 m
Electromotor power: 2 x 2,2 kW

Characteristics of Final Rffluent:

pH = 7-8
BOD5 < 25 mg O2/l
Susp. solids < 20 mg/l

6.3. BILL OF QUANTITIES AND COST ESTIMATIONS

6.3.1. Equipment

- Bar Rocks for process waste-water and sanitary waste water R-01 and R-02

  2 pcs 280 USD

- Mixer M-01

  N: 0,7 kW
  RPM: 210
  L: 1700 mm
  0: 450 mm

  1 pc 1.600 USD

- HCl Holding Tank V-01

  V: 5000 l
  0: 1400 mm
  H: 3450 mm

  1 pc 1.800 USD

- Dosing pump P-01

  Q: 1000 l/s
  H: 14 mWC
  N: 0,5 kW

  1 pc 3.700 USD

- Automatic HCl dosing System for pH-control (ACR-1)

  1 set 3.100 USD

- pH-end measuring and recording

  1 set 4.470 USD

- Biological Treatment unit BT-01

  Lenght: 15,6 m
  Width: 4,2 m
  Height: 5,0 m
  Electromotor power: 2 x 2,2 kW

	1 pc	108.900 USD
- Mounting (lump sum)		1.000 USD
TOTAL (6.3.1.):		123.850 USD

6.3.2. Civil works

1. Excavation of the surface layer, 30 cm thick

   (20 x 6 + 6 x 5) x 0,30 = 45

   m3 45 x 32 = 1.440 SP

2. Soil Excavation of the second, third, fourth and fifth category. It has been represented by 35, 35, 15 and 15 %. Total quantity is:

   7 x 6 x 2,50 + 19 x 7 x 3,20 = 530,60 m3

   2. ctg. m3 185,70 x 50 = 9.285 SP

   3. ctg. m3 185,70 x 57 = 10.585 SP

   4. ctg. m3 79,59 x 76 = 6.049 SP

   5. ctg. m3 79,59 x137 = 10.904 SP

3. Depositing of gravel screed

   5 x 4 + 5 x 16 = 100

   m2 100 x 70 = 7.000 SP

4. Casting of the concrete base screed, MB-10

   110 x 0,10 x 1000 = 11.000 SP

5. Casting of the basin by MB-30 concrete with addition of waterimpermeability admixtures. Casting should be carried out in smooth oil formwork with vibrating. Interruptions of casting and dilatations should be ensured by dilatation lines (Water Sto Coupling). Double formwork is included in the unit price.

   4,80 x 16,20 x 0,40 + 15,90 x 2 x 0,30 x 3 + 4,50 x

   x 2 x 0,30 x 3 + 4 x 4,80 x 0,15 + 4,50 x 4 x 0,40 +

   + 4,80 x 2 x 3,30 x 0,30 + 2,20 x 2 x 3,30 x 0,30 +

   + 3,20 x 0,30 x 2,60 + 1,70 x 2 x 2,60 x 0,30 +

   + 1,40 x 1,60 x 0,20 = 97,36

   m3 97,36 x 2000 = 194.720 SP

6. Filling up of the area on the site

   45 + 530,60 - 5 x 4 x 2,60 - 16,20 x 4,80 x 3,30=267

   m3 267 x 40 = 10.680 SP

7. Carting off the surplus excavation material.

   (5 x 4 x 2,60 + 16,20 x 4,80 x 3,30) x 1,25 + 267 x

   x 0,05 = 399 m3

   m3 399 x 50 = 19.950 SP

8. Reinforcing the concrete basin with ribbed bars according to static calculations and drawing of bending.

   97,36 x 80 = 7788 kg

   kg 7788 x 10,50 = 81.782 SP

9. Supply and erection of the steel enclosure around the basin

   m´ 18 x 120 = 2.160 SP

10. SUpply and building in of the mixer holder for the neutralizing reservoir. 2 U 14, 1600 mm long is built in.

    1,60 x 2 x 16 = 51,29 kg

    kg 51,20 x 15 = 768 SP

11. Locksmuthy foe BIO-ROLL equipment

    kg 600 x 25 = 15.000 SP

TOTAL(6.3.2.): 381.323 SP

eq 17.333 USD (1 USD = 22 SP)

RECAPITULATION (6.3.)

Equipment: 124.850 USD

Civil Works: 17.333 USD

TOTAL: 142.183 US

6.4. RUNNING COSTS

Basically, running costs (CR) consist of the following:

- maintenance costs (CM)
- energy costs (CE)
- costs for Chemicals (CC)
- labour costs (CL)
- depreciation costs (charges) (CA)

Maintenance costs (CM) are usually about 1,5 % of capital costs.

Energy costs (CE) consist of electric power and steam costs. Labour costs (CL) are applied according to the number of employed as well as the costs that are to be ensured for each employee.

Depreciation costs (CA) are applied with 6,7 % per annum of capital costs (based on the 15 year period exploitation).

NOTE: Running costs are computed only through newly suggested equipment. Working days per year 285.

- Chemical Costs (CC)

HCl-consuption: 400-500 l/d HCl (1:3)

500 l/day x 285 day/year = 142000 l/year

- Maintenance Costs (CM)

142.183 USD x 0,015 = 2.133 USD/year

- Energy Costs (CE)

M-01:	0,7 kW x 15 hr/day x 285 day/year =	2992 kW hr/year
P-01:	0,5 kW x 15 hr/day x 50 day/year =	375 kW hr/year
BT-01:	2x2,2 kW x 24 hr/day x 285 day/year=	30463 kW hr/year
	TOTAL:	33463 kW hr/year

CE = 33463 kW hr/year

- Labour Costs (CL)

One man 1 hr per diem

1 hr/day x 285 day/year = 285 man hr/year

- Depreciation Costs (CA)

CA = 142.183 USD x 0,067 = 9.526 USD/year

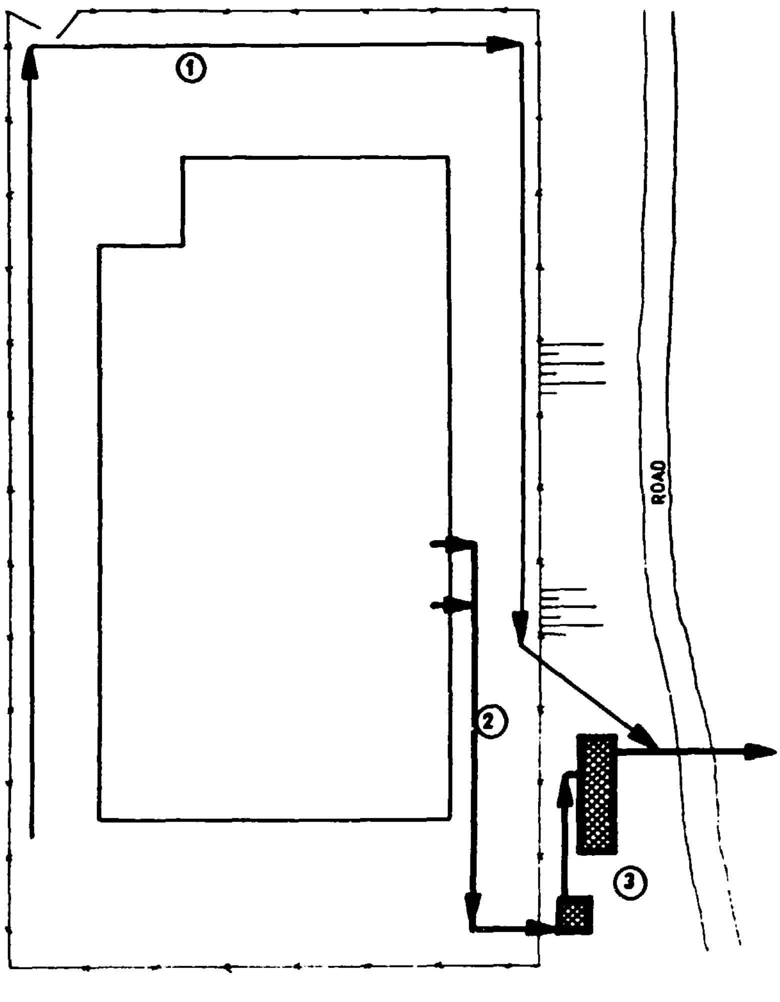
7. GENERAL CONCLUSIONS AND SUGGESTIONS

- The main problem in Drekish factory is turbidity of water for cola production. Since the problem exists only in winter period we suggest the usage of mineral surplus water for cola production. The connection of this water with the existing sand and carbon filters is the easiest and the cheapest solution. If sometimes in the future the market dictates the full production of mineral water even in the winter, raw industrial water would have to be treated chemically as suggested in Chapteer 5.3.2.

- Disinfection of water in food industry is of the highest importance and our suggestion is for GOFI to take care of the installaticn of the same type of fyllyautomatized systems in all of their factories enabling permanent and safe operations as well as proper maintenance and supply of spare parts. In Drekish Factory this problem has to be connected with the indusrial water sypply system avoiding unnecessary disinfection of the raw water surplus.

- The effluents from bottle washing are heavily polluted by alkalies and organic substances, so they have to be neutralised prior to biological treatment together with the sanitary effluents. The biological treatment can be performed in a separate industrial plant or together with other town effluents in the municipal plant.

8. DRAWINGS



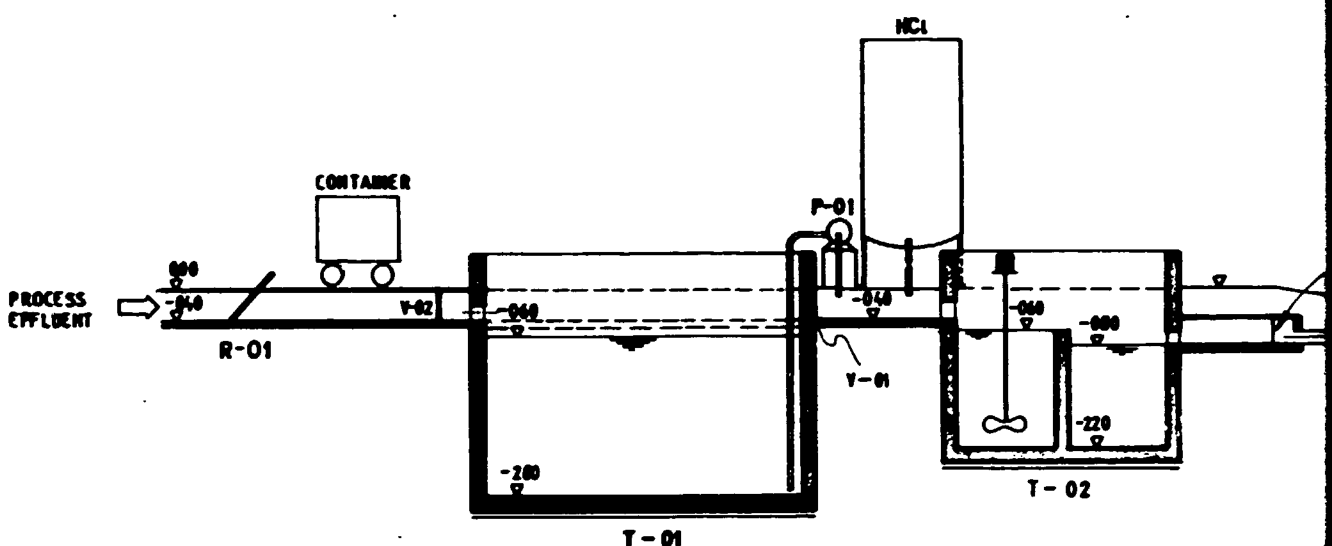
LEGEND.

① —— STORM WATER SEWER

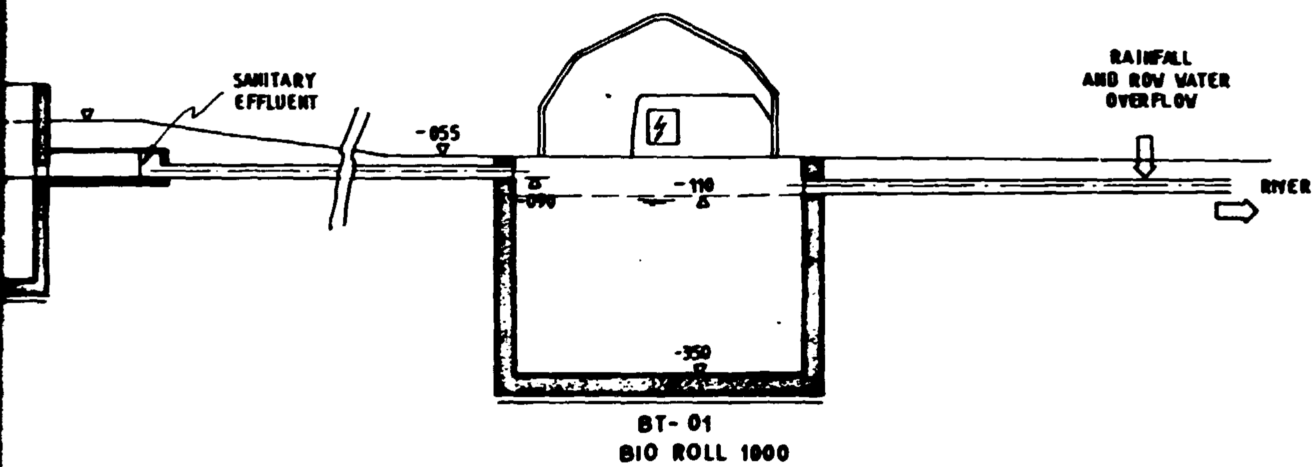
② ━━ PROCESS WASTE WATER SEWER

③ WASTE WATER TREATMENT PLANT

FIG. 3.13 WASTE WATER TREATMENT PLANT
Lay Out (preliminary)
Drekish Water Filing Factory

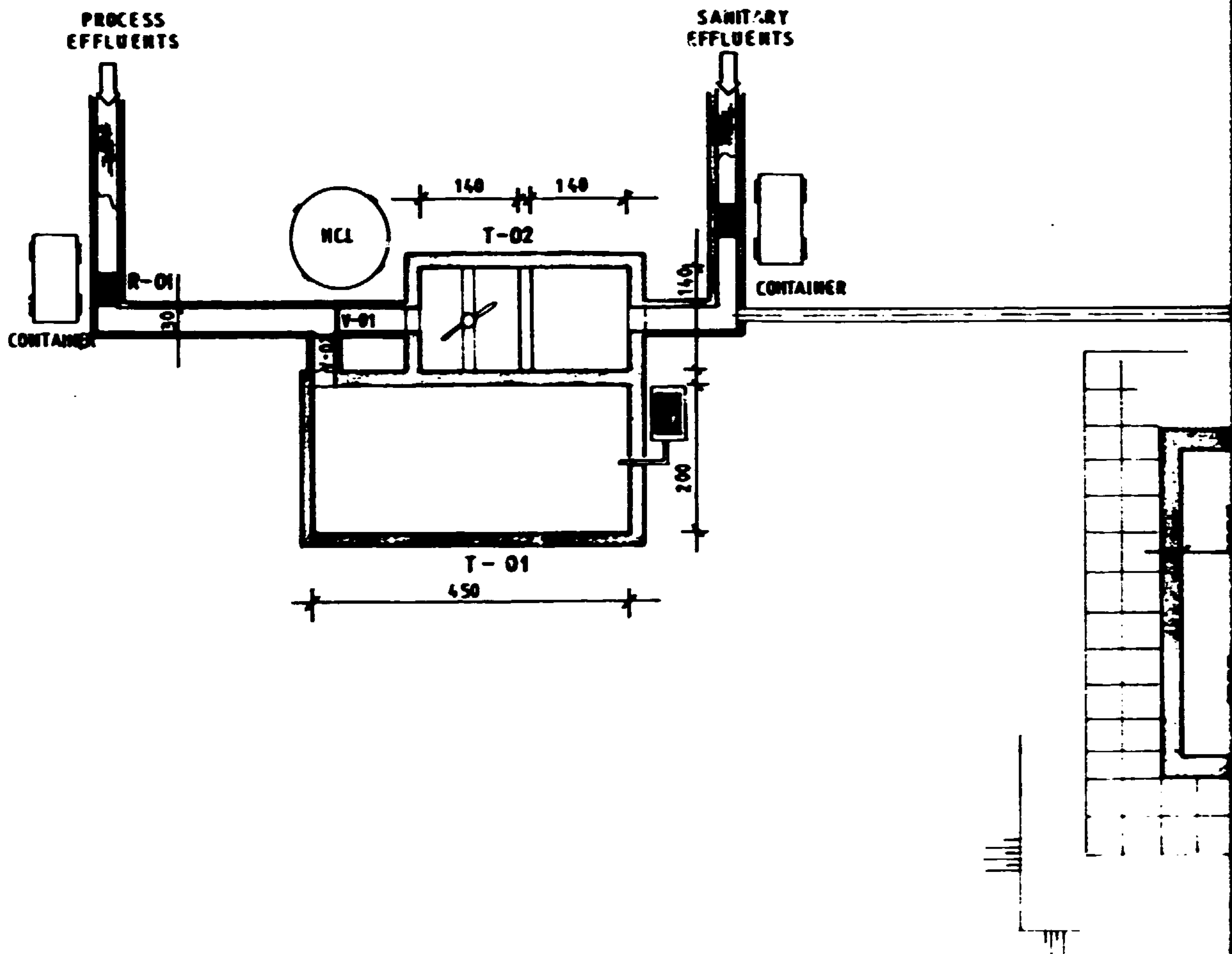

HCl
CONTAINER
P-01
PROCESS
EFFLUENT
R-01
V-02
Y-01
T-01
T-02
-200
-220

SECTION 1



SECTION .2

FIG. 3.14. PRETREATMENT AND FINAL BIOLOGICAL TREATMENT OF WASTE WATER
Cross-sectional View
Drekish Water Filing Factory


PROCESS EFFLUENTS
SANITARY EFFLUENTS
140
140
HCL
T-02
R-01
30
V-01
140
CONTAINER
CONTAINER
200
T- 01
450

SECTION 1

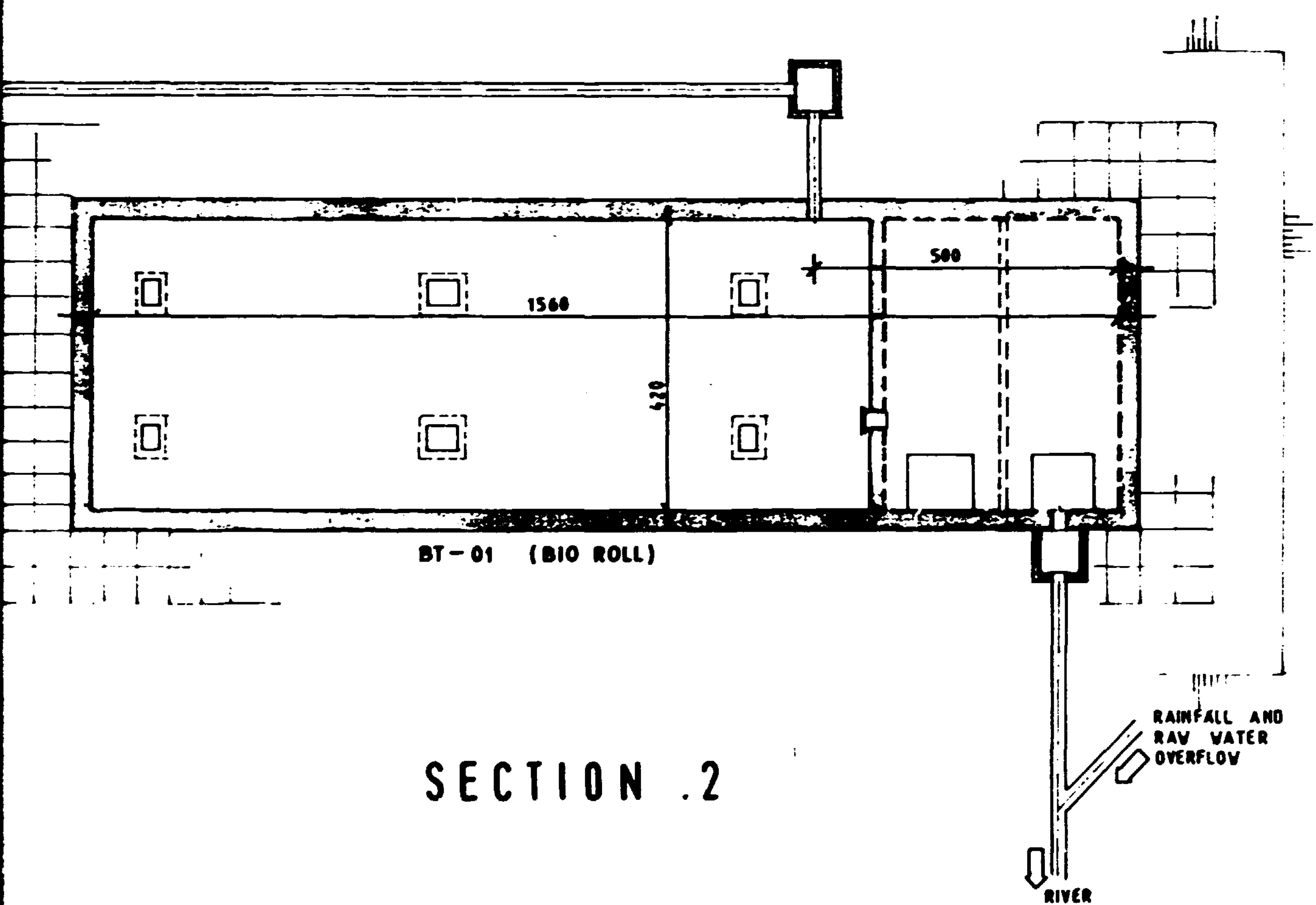


FIG. 3.15 PRETREATMENT AND FINAL BIOLOGICAL TREATMENT OF WASTE WATER
Plan View
Drekish Water Filing Factory