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POLLUTION CONTROL OF A FERTILIZER PLANT SITUATED IN A POPULATED AREA

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1. INTRODUCTION

There is no doubt that pollution has developed as one of the most serious problems that our society has to face in its way towards development.

The types of pollution fall into two main categories. Those for which science and technology have already given practical solutions for abatement and those for which either no solution has been proposed so far or the solutions proposed have not yet been materialized for various reasons.

Typical examples of the former are most industrial activities while for the latter, one could mention human activities in big cities like use of vehicles or production of wastewater from households. It is worth mentioning that such activities do not constitute by themselves a serious threat to the environment, while the heavy concentration of them taking place in a big city does.

The production of fertilizers in the broad sense results in gaseous, liquid and solid waste materials and is therefore classified as a polluting industrial activity. However, by taking advantage of modern pollution abatement techniques, the fertilizer industry, can survive and as a matter of fact coexist harmonically with its surroundings even if it happens to be a heavily populated area.

The case of the Hellenic Chemical Products and Fertilizers Co plant is a characteristic example which is presented here as a case study.

2. THE HELLENIC CHEMICAL PRODUCTS & FERTILIZERS CO

The Hellenic Chemical Products & Fertilizers Co (HCPF) founded in 1909 is the oldest Fertilizer Company in Greece, with main activities in the mining and chemical sector including fertilizers, acids, pesticides, flat glass and chemical products, as well as lead and zinc sulphides and pyrites.

The main production complex is situated at the entrance of the port of Piraeus which is part of the greater Athens area.

As it is shown in Fig. 1, this complex comprises the following plants:

. 400 tpd sulphuric acid plant (N° 3) which is a single absorption plant based on sulphur

. 700 tpd sulphuric acid plant (N° 4) which is a double absorption plant of mixed type i.e. based on sulphur and pyrites.

. 200 tpd (P_2O_5) phosphoric acid plant which is a Prayon plant producing weak 28% acid.

. 800 tpd SSP/TSP plant based on a Broadfield den.

. Two conventional NPK slurry granulation plants with capacities of 1200 tpd (N° 4) and 800 tpd (N° 5) respectively.

. 400 tpd compaction granulation plant using exclusively solid raw materials.

The main fertilizer grades produced are 16-20-0, 20-10-0, 11-15-15, 0-20-0 (SSP), 24-12-0, 14-14-14 etc. The production of the above plants is covering about 25% of the Greek market which is of the order of 2 million tonnes per year, while a small portion of it is also exported.

3. POLLUTION CONTROL IN THE PLANTS

3.1. Gaseous emissions

The contribution of the HCPF fertilizer complex to the overall pollution load of the Athens area, as far as gaseous emissions are concerned can be judged by inspection of the yearly average measurements of various pollutants in several local pollution recording stations which are shown in Tables 1 and 2.

In Table 1, the main pollution load in Athens is due to vehicles (75%) and to a lesser degree to industry (22%) although about 50% of the Greek industry is situated around Athens.

In Table 2, the level of pollution in the vicinity of the HCPF industrial complex in Drapetsona is well below the corresponding ones in the center of the city of Piraeus and Athens which are far away from HCPF.

In Table 3, the emissions of the sulphuric acid plants are compared to various standards and it is obvious that they are well below Greek (and EEC) standards and very near to EPA (USA) standards.

The gases from the single absorption plant are treated in an ammonia scrubber producing by-product ammonium sulfate solution which is recycled to the fertilizer plants.

The gases from the double absorption plant do not need such a treatment. To minimize emission of SO_3 the gases are passed through high efficiency Brink Mist Eliminators at the exit of the interpass absorption tower and also at the exit of the final absorption tower.

There is a continuous measurement and recording of SO_2 and SO_3 emissions in the stack which is integrated in a computer to produce hourly or longer period mean values.

In Table 4, the yearly average emissions of the main pollutants resulting from the phosphoric acid plant as well as the granulation plants are compared to the Greek and EPA standards.

These pollutants are namely fluorine and particulates (dust) although theoretically one could also include ammonia and SO_2/SO_3 resulting from dryer operations.

Regarding the phosphoric acid plant, dust control is effected by six filters integrated in the phosphate rock grinding loop. The ground rock is transported to the plant by means of a dust-tight air conveying system.

On the other hand, fluorine control in the phosphoric acid plant is effected via gas scrubbers which are of the Airmix type. Wherever appropriate, according to the relation of the scrubbing to the process stage, and especially at the final step, scrubbing is accomplished by sea instead of process water as sodium contained in the sea water is reacting with fluorine more efficiently to create sodium silicofluoride (Na_2SiF_6).

The problem of odour which is mainly due to the content of organics in the phosphate rock cannot be tackled by scrubbing so the only remaining choice is to select phosphate rock by including in the criteria for selection this decisive element.

The final scrubbing of the gases of the conventional NPK granulation plants is accomplished also by sea water which is used not only for fluorine removal from the gases but also to condense some amount of steam resulting from the process.

Prior to that, the gases from the reactor and the granulator are treated in a turbulent contact absorber (TCA) by dilute sulphuric acid solution reacting 100% with anhydrous ammonia slipping out of the primary reaction. To keep this ammonia slip to a minimum, ammoniation rate of the reaction slurry is kept in the range of 1.

The packing of the TCA tower consists of polypropylene or polyethylene spheres in which dust is also trapped.

The gases resulting from the dryer are also scrubbed by dilute sulphuric acid solution in an Airmix type scrubber or alternatively in a cyclonic tower.

In order to control dust arising from fertilizer raw materials or product transportation within the plant, each plant is equipped with an independent dedusting loop.

In the case of the compaction plant of course, the only pollution control required is that of dust which is easily and efficiently performed by a series of cyclones and air filters.

3.2. Wastewater Treatment

Although scrubbing in the various fertilizer plants is performed in closed circuit scrubbing systems, saturation of the scrubber liquor, mainly by dust, requires bleeding off part of this saturated solution. The lack of strong phosphoric acid on the other hand creates a water surplus in the system and despite all process manipulations it makes impossible the complete recycling of the above bleed.

As a result, a small stream of wastewater is created which together with sea water coming out of the final condensing scrubbers should be properly treated before it is discharged to the sea.

As mentioned above, sea water is used in huge quantities in the plants. Part of it is used for cooling purposes only (mainly in the sulphuric acid plants) while the rest is used for final scrubbing in the fertilizer plants. It is this latter part which is mixed with all other wastewater and is treated in the waste water treatment plant. The effluent of this plant which is much cleaner than the incoming sea water in the fertilizer plant is then mixed with the rest of sea water (used for cooling purposes) and is discharged to the sea.

Figure 2 describes in simple lines the waste water loop.

As the main pollutants to be removed from the wastewater are F and P_2O_5, treatment is effected by lime which precipitates these pollutants in the form of CaF_2 and $Ca_3(PO_4)_2$, which form a sludge, while the treated water overflows and is discharged to the sea.

The resulting sludge is dehydrated in a filter press which produces an almost solid cake and a small stream of contaminated water which is recycled to the treatment plant.

The final stream of water which is produced by mixing the output of the treatment plant with the cooling water should have the following characteristics before it is discharged to the sea:

pH	: 6.5 - 9.0
F	: $<$ 6 mg/1 t
P	: $<$ 10 mg/1 t
Suspended solids	: $<$ 40 mg/1 t
T	: $<$ 32° C

The quality of effluents is continously measured by pumping a small sample to an automatic analyzer.

The effluents from the SSP plant (which is operating only part of the time) which are heavily contaminated in F are separately treated in a closed loop out of which fluorine rich sludge is removed so that efficient scrubbing of gases is obtained. This helps to keep the consumption of lime relatively lower than in the case of mixing this stream with the rest of water to be treated.

3.3. Solids

The main solid waste material resulting from the fertilizer complex is gypsum discharged from the Prayon filter of the phosphoric acid plant.

Up to 1978, gypsum was discharged to the sea. Thereafter, it is transported by trucks to an old quarry situated about 10 km from the plant, where it is discharged in a way that aims at reestablishing the original slope of the mountain. Recently, considerable effort is put in developing horticulture that could fit in this environment.

It is interesting, to note that the specific area of dumping was chosen not only because it is relatively close to the plant but also because underground soil configuration is such that it excludes any possibility of underground water contamination due to leakage from the gypsum, as there are no underground water passages in the area.

Apart from the gypsum which exceeds 1000 tpd, another solid waste that is deposited in the same area is the cake of the filter press of the waste water treatment plant which however is much less than 100 tpd.

Another solid waste material is the pyrite cinder which is iron oxide produced in the roaster. This is sold to local cement manufacturers. Due to its fineness, special care is taken for its transportation. Trucks employed for this job are all covered and before they leave the plant their wheels are washed with water, to prevent formation of dust.

4. COST OF POLLUTION ABATEMENT

Considering all the above, it is obvious that the cost of pollution abatement in a plant situated in the middle of a residential area is really high.

Continuous new investment to keep up with advancing technology and operating costs for pollution control equipment create an additional more that $ 10 charge per tonne of final product.

However, it cannot be claimed that this is a waste of money as it does have some positive results such as:

. It creates the appropriate working and living conditions for people that work within the plant and people that live in the neighbourhood of the plant. It is important that both of them are healthy and happy.

. It safeguards the existence of the plant in an area with strategic importance as far as distribution of fertilizers is concerned.

. Considering that the cost of fertilizer depends mainly on the cost of raw materials, reduction of emissions or wastes leads to cost savings for example in the case of reducing SO_2, SO_3 in gaseous emissions or P_2O_5 in water effluents.

Figure 3 shows how N, P, K losses in wastewater were considerably reduced following a programme of monitoring the quality of effluent wastewater.

It is anticipated that by concentrating the phosphoric acid, it will be possible to further reduce these losses, and at the same time, reduce the quantity of P_2O_5 discharged to the sea.

5. CONCLUSIONS

As it is concluded from the above, survival of a fertilizer plant in a residential area takes considerable effort, requires constant alert, and costs accordingly.

However, the control of effluents is a process which not only safeguards the functioning of the industry according to environmental legislation but at the same time, affects optimization of production processes and minimization of production costs.

This new dimension in which pollution abatement is a way of reducing losses of valuable raw materials or intermediate or final products provides a strong incentive for a cleaner environment.

TABLE 1

TOTAL YEARLY EMISSIONS IN GREATER ATHENS AREA

SOURCE OF EMISSION	VEHICLES		CENTRAL HEATING		INDUSTRY		TOTAL
POLLUTANTS	tpy	%	tpy	%	tpy	%	tpy
SMOKE	3300	64	859	17	1035	19	5194
PARTICULATES	90				21206	100	21296
SO_2	1410	7	3690	21	12696	72	17796
NO_x	17400	67	1391	5	7181	28	25972
CO	323750	100	380		449		324579
HYDROCARBONS	46200	65	190		25900	35	72200
% CONTRIBUTION		75		3		22	

TABLE 2

YEARLY AVERAGE MEASUREMENTS OF SMOKE, PARTICULATES AND SO_2 IN GREATER ATHENS AREA

AREA OF MEASUREMENT	SMOKE mg/m^3			PARTICULATES mg/m^3			SO_2 mg/m^3		
	1984	1985	1986	1984	1985	1986	1984	1985	1986
ATHENS CENTER	190	172	140	145	126	-	33	32	-
PIRAEUS CENTER	87	83	61	-	-	-	29	27	-
DRAPETSONA (HCPF)	36	33	24	176	151	-	26	26	31

TABLE 3

YEARLY AVERAGE EMISSIONS FROM SUFLURIC ACID PLANTS

SO_2

PLANT	MEASURED EMISSION SO_2		STANDARDS		
			GREEK		EPA
			OLD PLANTS	NEW PLANTS	
	ppm	kg/t*	kg/t*	kg/t*	kg/t*
No 3	300	2.8	10	(6)	2
No 4	229	1.5	10	(6)	2

* per tonne of product H_2SO_4

SO_3

PLANT	MEASURED EMISSION SO_3		STANDARDS		
			GREEK		EPA
			OLD PLANTS	NEW PLANTS	
	mg/m^3	g/t*	g/t*	g/t*	g/t*
No 3	32	104	800	(500)	75
No 4	70	163	800	(500)	75

* per tonne of product H_2SO_4

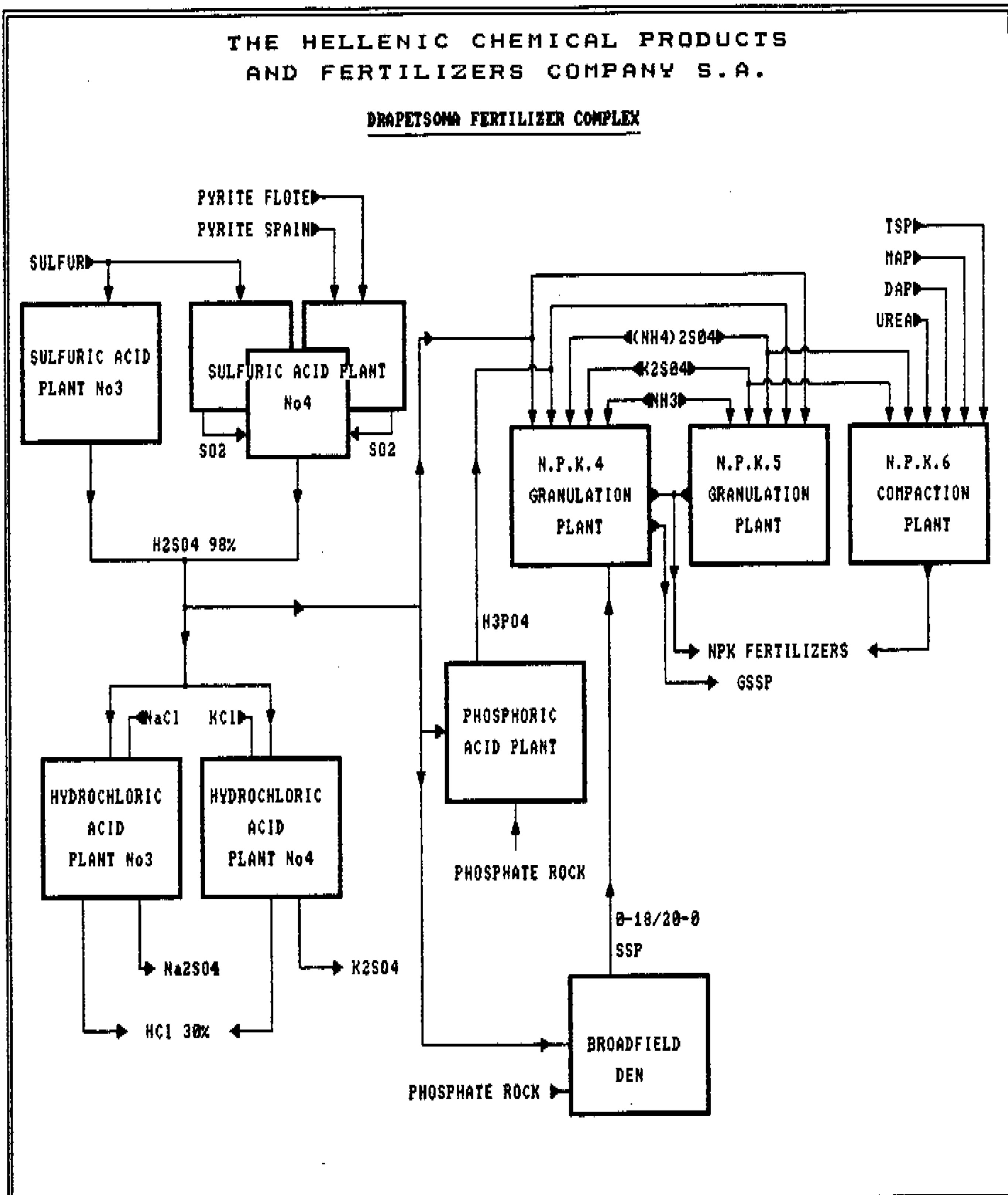
TABLE 4

YEARLY AVERAGE EMISSIONS FROM FERTILIZER PLANTS

FLUORINE	MEASURED EMISSION		STANDARDS		
			GREEK		EPA
			OLD PLANTS	NEW PLANTS	
	mg/Nm^3	$g/t\ P_2O_5$	mg/Nm^3	mg/Nm^3	$g/t\ P_2O_5$
PHOS.ACID	3.4	8	100	80	10
N.P.K. 4	2.6	53	100	80	30
N.P.K. 5	0.8	29	100	80	30
SSP PLANT	4.5	19	100	80	–
TSP PLANT	1.3	4	100	80	100

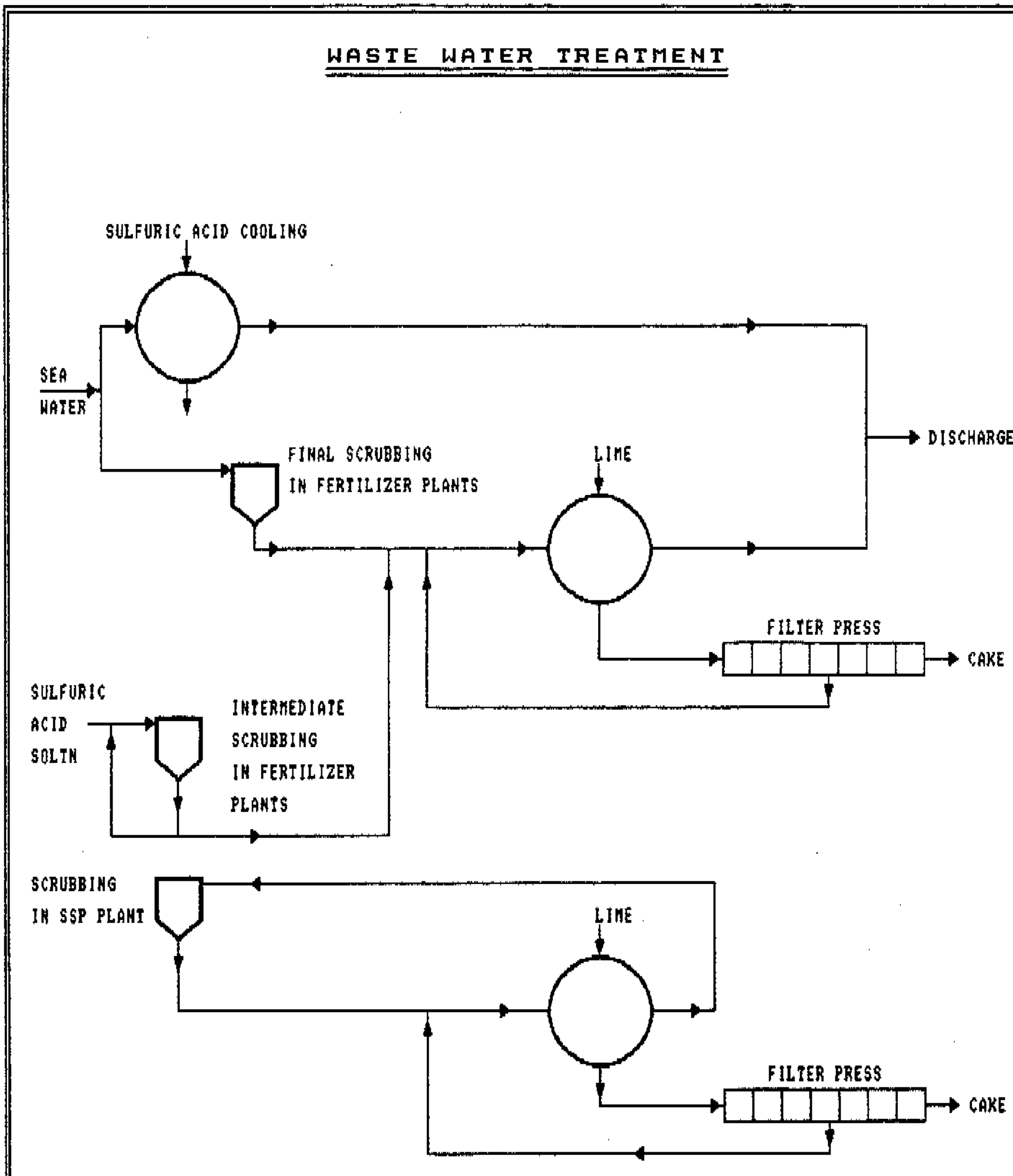
PARTICU-LATES	MEASURED EMISSION	STANDARDS	
		GREEK	
		OLD PLANTS	NEW PLANTS
	mg/Nm^3	mg/Nm^3	mg/Nm^3
PHOS.ACID	57	150	100
N.P.K. 4	57	150	100
N.P.K. 5	35	150	100
SSP PLANT	123	150	100
TSP PLANT	12	150	100

FIG:1



THE HELLENIC CHEMICAL PRODUCTS
AND FERTILIZERS COMPANY S.A.
DRAPETSONA FERTILIZER COMPLEX
PYRITE FLOTE
PYRITE SPAIN
SULFUR
SULFURIC ACID PLANT No3
SULFURIC ACID PLANT No4
SO2
SO2
H2SO4 98%
NaCl
KCl
HYDROCHLORIC ACID PLANT No3
HYDROCHLORIC ACID PLANT No4
Na2SO4
K2SO4
HCl 30%
TSP
MAP
DAP
UREA
(NH4)2SO4
K2SO4
NH3
N.P.K.4 GRANULATION PLANT
N.P.K.5 GRANULATION PLANT
N.P.K.6 COMPACTION PLANT
H3PO4
NPK FERTILIZERS
GSSP
PHOSPHORIC ACID PLANT
PHOSPHATE ROCK
0-18/20-0
SSP
BROADFIELD DEN
PHOSPHATE ROCK

FIG:2


WASTE WATER TREATMENT
SULFURIC ACID COOLING
SEA WATER
DISCHARGE
FINAL SCRUBBING IN FERTILIZER PLANTS
LIME
FILTER PRESS
CAKE
SULFURIC ACID SOLTN
INTERMEDIATE SCRUBBING IN FERTILIZER PLANTS
SCRUBBING IN SSP PLANT
LIME
FILTER PRESS
CAKE

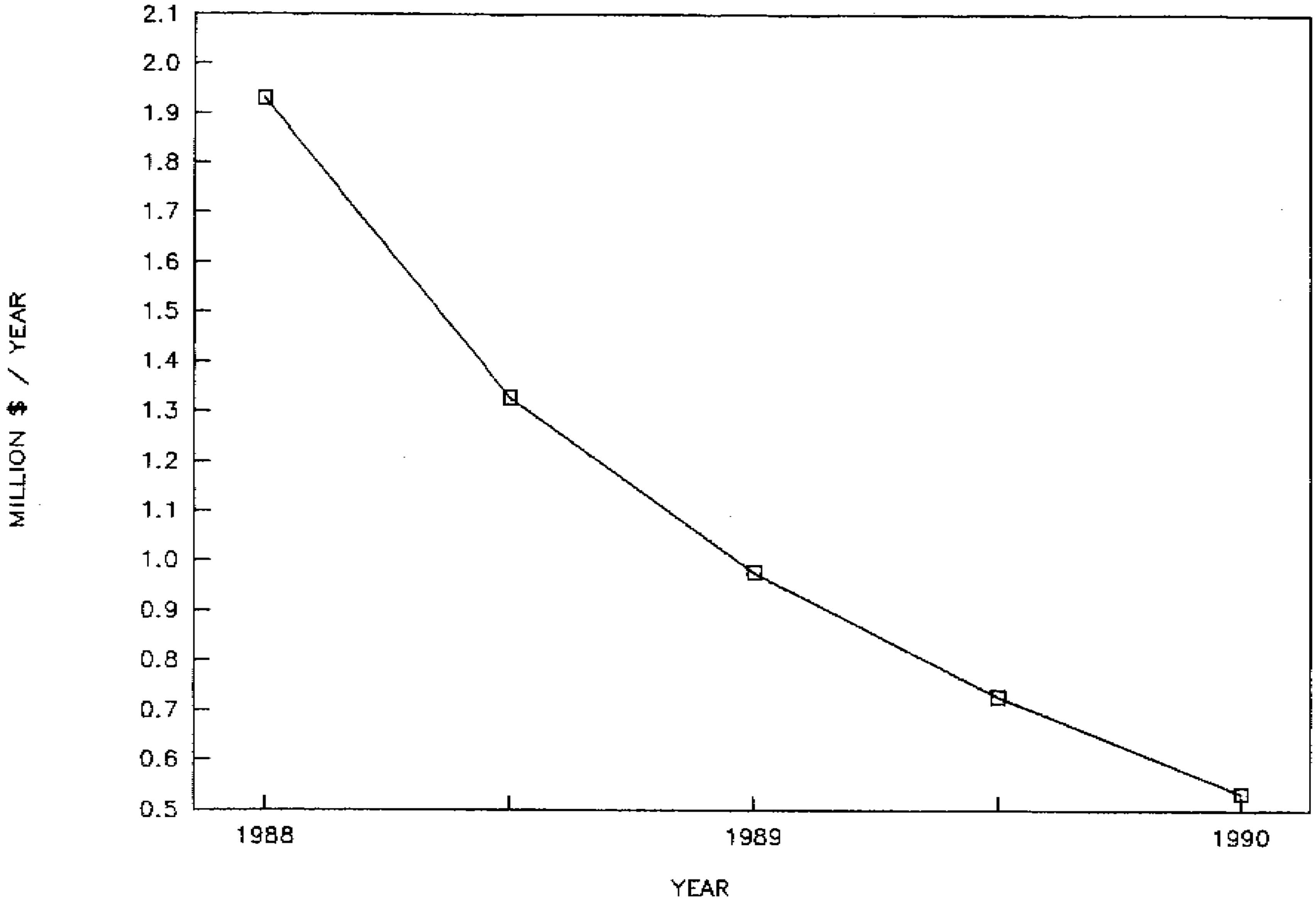


FIG:3 N-P-K LOSSES IN LIQUID EFFLUENTS