
**ENVIRONMENTAL DEGRADATION AS THE RESULT
OF NATO AIR - RAIDS AGAINST PANČEVO
CHEMICAL PLANTS – OIL REFINERY /
PETROCHEMICAL PLANT /
AZOTARA FERTILIZER PLANT**

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NIS - Oil Refinery, Pančevo, Yugoslavia

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ABSTRACT

The long period of sanctions followed by the NATO air raids against the chemical plants of Pančevo caused ecological disaster of enormous proportions in the district, leaving the consequences to the population of the region, making it a transboundary issue of utmost urgency and importance. Due to the impossibility to organize the running under normal conditions during a decade of sanctions imposed on our country, the mentioned companies were constantly facing difficulties concerning the purchasing of the raw materials, devices and equipment since the export to FRY was banned. Thus the companies have been prevented from the realization of the environmental programs and plans including the introduction and implementation of new technologies having as the objectives the remediation of the already existing environmental problems, instead the environmental degradation was increased. During the period from 4th April – 7th June 1999, Pančevo was targeted by the NATO on seven occasions. The area where the chemical plants are located was targeted with 35 missiles causing not only the damages but also endangered the environment of Pančevo and the consequences remain to be monitored in the coming years. Three employees of the Oil Refinery were killed at work while more than 50 were injured. Approximately 58.500 tons of crude oil, oil derivatives, vinylchloride monomer and other petrochemical products and components were burnt in fire. Serious spills of approximately 5.000 tons of crude oil, oil derivatives, 23.000 tons of EDC, 600 tons of HCl, 8 tons of mercury, 3000 tons of NaOH, 230 tons of ammonia water and ammonia and large quantities of other toxic substances contaminated the surrounding soil, ground water, the waste water canal and the river Danube. The sewerage systems were seriously damaged and blocked. A considerable damage was caused to the wastewater treatment facilities resulting in pollution of HIP-Azotara wastewater canal and the river

Danube. The contamination of the sites and the surrounding area came as the consequence of fire and the incomplete combustion causing enormous emissions of nitric oxides, sulphur oxides and carbon oxides, soot particles with the hydrochlorides adsorbed, incompletely combusted hydrocarbons, carcinogenic aromatic compounds, dioxins, phosgene and other hazardous material. Testing of soil samples, surface and ground water samples as well as of the wastewater canal sediment by both domestic and foreign experts showed the presence of the large quantity of detrimental and toxic materials. The wastewater canal 1,8 km long currently is the focus of contamination in the oil-chemical complex. The total amount of the estimated damage caused to the three companies reached the sum of 904 millions US\$. The direct environmental damage amounts approximately 43,5 millions US\$. The consequences of the long-term environmental degradation remain to be estimated during the coming years. Priority plans and programs for the remediation and monitoring of the environment have been prepared in cooperation with UNEP, while some of them are still under preparation. Currently, the shortage of the financial funds represents the obstacle to the realization of the environmental remediation projects.

Key words: chemical plants, air raids, environmental degradation

INTRODUCTION

The town of Pančevo, (app. 80.000 inhabitants), is located app. 20 kilometers from Belgrade to the north-east, on the mouth of the river Tamiš into the Danube, in the closest vicinity of major highways, railways and waterways. A navigable canal, 2 kilometers long connects the plants to the Danube and provides the most economic transportation of products and raw-materials, thus meeting the demands for the construction of the largest river port and free – trade zone in Central and Southern Europe.

After the WW2, the large industrial complex consisting of the Oil Refinery, the Petrochemical Plant and the Fertilizer Plant has been built in the southern edge of Pančevo, during the era of the “socialist economy” expansion.

The chemical complex of Pančevo is located 2,5 km far from the city edge in the vicinity of the residential area of Vojlovica and Topola. The chemical complex consists of NIS Oil Refinery, HIP Petrochemical Plant and HIP Azotara Fertilizer Plant.

The technological processes of the mentioned plants are based on the use of high pressures and temperatures together with the hazardous, toxic and corrosive materials. Therefore, the industrial area presents the constant potential high risk both to the environment and human health in case of fire, explosion, poisoning and leakage.

I. PANČEVO OIL REFINERY

BUSINESS LINE

Pančevo Oil Refinery is the largest oil derivative producer in Yugoslavia and it is a part of the state-owned company - Petroleum Industry of Serbia.

The designed processing capacity of the Refinery is 4.820.000 t/day of crude oil. According to its production structure, it is a fuel type refinery, which means that its main products are fuels, i.e. liquid petroleum gases, motor and aviation gasolines, kerosenes, diesel fuels and fuel oils. The Refinery produces other oil derivatives as well, such as aromatics, paraffinic and aromatic solvents, feedstock for the petrochemical industry, bitumens and sulphur. With its process units and applied technologies, being mostly from the West, the Refinery can achieve a high quality product structure, consisting of over 80% of white products. There are about 2200 employees in the Refinery.

NATO BOMBING AND ITS EFFECTS ON THE ENVIRONMENT

From 04 April to 07 June 1999, Pančevo Oil Refinery was bombed seven times by NATO aviation with more than 25 missiles of tremendous destructive power, thus causing enormous material destruction and serious consequences on the environment. At that time, three Refinery employees were killed, and over forty employees were injured, more or less seriously. There were significant material and other damages on process units, power and storage facilities, infrastructure, other civil structures and stored products (crude oil and oil products). The total estimated damage amounts to approximately 362.6 million US\$, out of which the damage caused to the fixed assets and the working capital is about 298.2 and 64.4 million US\$ respectively. Environmental damage being the subject of the remediation project is approximately 10 million US \$.

ENVIRONMENTAL CONSEQUENCES OF THE BOMBARDMENT

By destroying the Refinery over 62.000 tons of crude oil and its derivatives were destroyed.

Table 1- Destroyed products and crude oil in the Refinery

TYPE	QUANTITY (t)	PERIOD
Crude oil	9.260	12-18 April
Crude oil	28.440	07-14 June
LPG	230	11-12 April
Benzene	80	11-12 April
Special gasolines	360	11-12 April
Straight-run gasoline	1.500	11-12 April
Motor gasolines	4.350	11-12 April
Kerosenes	1.240	11-12 April
Diesel fuel	350	07-08 June
HVGO	6.660	17-25 April
Fuel oil	7.550	17-25 April
Products off spec.	1.890	11-12 April
TOTAL	61.910	

The greatest part of crude oil and its derivatives, about 57.000 tons, burned due to the explosion and fire, thus polluting closer and wider surroundings of the Refinery and the clouds carrying harmful substances were reported to have reached the neighbouring countries as well.

Due to incomplete combustion, in addition to CO₂, SO₂ and NO_x, great quantities of soot, partially burnt hydrocarbons, carcinogen aromatic compounds, and other substances, were emitted into the air, jeopardizing and contaminating a wide area, but mostly local population and soil

It is estimated that about 5000 tons of crude oil and oil products poured out and, together with solid combustion products and fire-fighting substances, polluted the ground in the Refinery and, as an emergency measure, was discharged into the Danube.

According to the estimates, the total area of the soil in the Refinery contaminated by the spilling of crude oil and its products is about 95.000 m², with the different depths of pollution depending on the soil composition and the quantity and kind of the spilled substances. Soil thus contaminated is extremely hazardous because of possible penetration of harmful substances into the groundwater. Significant quantities of spilled substances, together with the soil, got into the oily and rainwater sewer, as well as into the primary waste water processing unit (API Separator), which directly jeopardized the quality of water discharged into the Danube. In addition to this, the destroyed tanks of crude oil and oil products contain large quantities of hazardous sediments which have to be treated before removed.

About 400 tons of extracts and 10 tons of foam was spent for fire extinguishing in the Refinery. Besides the Refinery own fire-fighting department, fire brigades from the Petrochemical Complex and the Fertilizer plant also took part in fire extinguishing, together with the territorial fire brigades from the Ministry of Internal Affairs of Serbia, located in Belgrade and Pančevo

It must be pointed out that owing to appropriate safety measures and well organized preventive actions within the Refinery, the extent of the environmental consequences of the destruction caused by NATO bombing has been significantly reduced..

ENVIRONMENTAL POLLUTION

The direct consequence of bombing the Refinery is enormous contamination of air, soil and water.

CONTAMINATION OF AIR

The emissions of harmful substances into the air due to the fire, caused by the burning of crude oil and products, in the quantities and the duration given in Table 1, are presented in Table 2, based on the quality of crude oil and products, as well as the emission factors given by UNEP Balkan Task Forces.

Table 2 Emissions of harmful substances due to the fire in Refinery

<i>Pollutant</i>	Total emission (t)
SO ₂	1.700
NO _x	400
Solid particles	870
Soot	240
Organic carbon in particles*	400
Polycyclic aromatic hydrocarbons (PAH)	40

*Organic compounds in particles converted to carbon

Considering that these emissions took place in relatively short time, i.e. while the fires were raging at which time thick smoke reached the height of several hundred metres, their negative effect on the health of people, as well as on flora and fauna was surely tremendous.

The highest ground level concentrations of pollutants were several kilometres away downwind from the fire itself, and they are presented in Table 3.

Table 3 Ground level concentrations of pollutants

Pollutant	Emission (g/sec)	Wind velocity (m/sec)	Cross-sectional Area of plume (km²)	Ground level concentration (µg/m³)
SO ₂	9.600	3-5	4-8	200-800
NO _x	2.200	3-5	4-8	50-200
Solid particles	4.800	3-5	4-8	100-400
PAH	220	3-5	4-8	5-20

The values of pollutant ground level concentrations during the fire were, depending on the wind direction, very high and significantly above the permissible concentrations.

As a result of the fire, caused by the burning of crude oil and its products in the Refinery, in addition to the stated pollutant emissions, there was also the creation of the so-called tropospheric or ground level ozone. As generally known, this ozone is formed from hydrocarbons, sulphur radicals, halogen compounds, nitrogen oxides and formaldehyde under the influence of UV radiation. In addition to destroying the ozone layer in the stratosphere, creating ozone holes, tropospheric ozone, same as CO₂, shows green house effects, and, as such, is aggressive both to people and entire flora and fauna. Its presence increases the acidity of atmosphere because acid aerosoles dissolved in water drops cause the formation of strong acids, such as H₂SO₄ and HNO₃, known as acid rains.

CONTAMINATION OF GROUNDWATER

The Refinery controls the quality of groundwater, taking samples from 31 piezometres located all over the Refinery, some of which were damaged during the bombardment. Table 4 presents the quantities of organic substances dissolved in organic solvents, the so-called "bitumen fraction" in groundwater samples taken before and after NATO bombing. The analyses were performed by the Chemical Faculty in Belgrade.

It can be seen that the quantities of organic substances in the samples from September 1999, meaning after the bombing, are considerably higher than in the samples taken before. Obvious threat of groundwater contamination by the spilt crude oil and products has been confirmed by UNEP in its analyses; their results of groundwater samples from July 1999 and February 2000 are given in Table 5.

The values in Table 5 for aromatics and hydrocarbons are many times increased in comparison to their MPL (maximum permitted level) in drinking water, and extremely increased content of 1,2 dichloroethane is surely a consequence of groundwater migration from the direction of Petrochemical Plant, where this substance was spilled.

Groundwater samples taken after the bombardment and analyzed in the Refinery Laboratory also showed increased concentrations of some metals in comparison with the

MPL; special attention is paid to the control of lead content which was increased due to the spillage of motor gasolines containing lead additives.

Table 4 Quantity of organic substances in groundwater samples taken in the Refinery for the period from 1997 to 1999 (mg/1000 cm³)

Piezometer No.	Organic Substance autumn /winter 97/98	Organic Substance spring 98	Organic Substance Autumn 98	Organic Substance autumn 99
<i>B1-11</i>	30,5	8,1	1,0	-
B2-20	40,0	4,8	2,5	104,5
B3-20	45,0	7,6	3,5	122,0
B1-21	858,0	194,4	424,5	813,5
B2-21	129,0	6247,6	18,0	343,5
B3-21	32,0	6,4	7,0	138,0
B1-22	24,5	11,9	1,5	112,5
Pt1-24	50,0	8,5	6,5	126,5
Pt2-24	12,0	5,2	9,0	104,5
Bu3-24	41,0	21,4	415,5	3026,0
B4-24	54,0	4,8	1,0	108,0
B6-24	15,5	3,7	1,5	137,5
Bz1-24	15,0	8,3	4,5	97,5
B3-24	35,5	3,5	8,0	141,5
B1-24	-	7,1	-	358,0
B1-9	23,0	15,2	15,0	-
B1-16	9,0	6,5	5,0	114,0
B1-19	11,5	6,1	-	143,5
B2-16	12,5	3,6	-	-
B2-22	10,5	8,5	3,5	118,5
B1-3	-	-	-	112,5
B1-18	-	-	-	126,5
B1-14	-	-	-	102,5
B1-4	-	-	-	1573,0
B1-17	-	-	-	144,5

ENVIRONMENTAL REMEDIATION OF THE CONSEQUENCES OF REFINERY BOMBARDMENT

In order to eliminate environmental consequences of Refinery bombing, especially the oily and contaminated soil and consequently jeopardized groundwaters, and also in order to repair the sewer pipelines and oil-separator, the Refinery has prepared, together with UNEP Balkan Task Forces, an activity plan that is implemented along with the Refinery reconstruction.

Table 5 Content of aromatics, hydrocarbons and 1,2 dichloroethane in Refinery groundwater samples taken in July 1999 and February 2000

PARA METE RS (µg/l)	B1-19		B1-3		B1-16		B6-24	
	July 1999	Feb. 2000						
BTEX (Total)	4200	1841	860	157,4	74	442	720	531
Benzene		248		91		214		148
Toluene		536		19		46		133
Ethyl Benzene		139		5,4		31		44
Xylene		918		42		151		206
HC	6000	14600	1200	740	398	340	970	920
PAH	70				225			
1,2 dichloro ethane		53300		41900		10200		10900
Phenol	157		1				3,2	

PARA METE RS (µg/l)	B2-21 Feb. 2000	Pt1-24 Feb. 2000	B1-14 Feb. 2000	B1-17 Feb. 2000	B1-4 Feb. 2000	MPL In drinking water
BTEX (Total)	30750	8572	845	849	142	
Benzene	9100	7380	83	295	36	1
Toluene	4820	114	154	160	49	700
Ethyl Benzene	5330	8	61	113	3	2
Xylene	11500	1070	547	281	54	50
HC	109000	2300	380	1950	4700	10
PAH						0,2
1,2 dichloro ethane	66900	5300	56500	23700	9610	3
Phenol						1

PAH-Polycyclic aromatic hydrocarbons

Based on the collected documentation and soil and groundwater samples taken from the field, UNEP experts have prepared a Feasibility Study for the remediation of the contaminated areas, within which there are five remediation projects for the Refinery.

1. Remediation of contaminated soil

The project includes:

- Contaminated soil mapping
- Cleaning and removal of contaminated soil to designated location
- Remediation of soil, where about 90% is treated microbiologically by applying the so-called Biofil, and about 10% of extremely contaminated soil is planned to be thermally treated by burning in the cement factory. The treated soil can be returned or applied to the walls of tank yards.

The planned remediation time is two years, with the determined priorities.

The total planned costs are 3.886.000 US\$.

2. Remediation of free phase oil on the groundwater table

Remediation of free phase oil on the groundwater table is planned to be performed in-situ. A method has been suggested that is based on simultaneous vacuum extraction of free phase oil and volatile compounds above the groundwater level.

The planned time of these works is thirty months, and estimated costs are 356.000 US\$.

3. Cleaning and repair of sewer pipelines and oil-separator

After the inspection of the sewer pipelines, which includes optical survey of underground pipelines as well, various cleaning methods have been planned and depending on the degree of fouling, they range from application of warm water, steam and solvents to the application of pressure equipment for the most clogged places. After that, the damaged pipe parts and the damaged equipment shall be replaced in oil-separator (API-Separator).

The planned duration of works is eight months, and estimated costs 1.716.000 US\$.

4. Construction of a concrete basin for oil sludge

This project presents the construction of a temporary storage with the capacity of 1.700 m³ for the oil sludge coming from cleaning the oil sewer and oil-separator. This storage is also planned for the spilled oil coming from the damaged parts of the oil sewer.

The estimated construction costs are 185.000 US\$.

5. Groundwater monitoring programme on the Oil Refinery

This project presents the preparation and implementation of monitoring programme in the duration of thirty months, by applying the existing piezometres in the Refinery.

The planned costs are 74.000 US\$.

The total, estimated financial means for the implementation of all five projects according to the UNEP's Feasibility Study, are 6.217.000 US\$.

As a part of remediation activities, the Refinery plans the construction of a unit for the treatment of oil sludge from the concrete basin.

Planned costs for that unit are 2.000.000 US\$.

For repair and replacement of the damaged equipment and reconstruction of the gravity API separator aiming at the better refinery waste water treatment, Refinery is planning to use additional funds of 900.000 US \$.

For the cleaning of destroyed concrete surfaces and polluted soil in pump houses 11 and 15, as well as for laying of the new concrete, the budget of 350.000 US \$ has been planned.

The Refinery is also planning some addition funds for oily soil microbiological treatment in the Refinery amounting to about 550.000 US \$.

Additional funds for the environmental remediation in the amount of 3.800.000 US \$ Refinery have been planned on the basis of an estimate.

The Refinery has spent about 250.000 US \$ from its own budget, for the cleaning of some ground surfaces, tank yards, some part of the oily sewer, etc.

So far UNEP/UNEPS have provided donated funds for the financing of Project no. 4 in the amount of 185.000 US\$, while other projects, although urgent, are still uncertain.

of the process units were shut down for a long period of time, due to the ban of crude oil import and only few units operated part-time with the domestic crude oil available, had negative impacts on the condition of the equipment and its revitalization.

Limited financial funds after the bombardment enabled only unit reconstruction with the existing 25-30 year old technologies which, with the import of high sulphur crude oils, additionally affects the environment.

Besides a direct detrimental impact on the environment, the Refinery, due to its obsolescence, also indirectly affects the human surroundings, being unable to keep pace with the quality improvements prescribed by the EU (motor gasolines, diesel and fuel oils).

For the modernization and revamp of its units after the isolation period and in order to start producing better quality, environmentally pure products in compliance with the EU regulations, carry out environmental remediation and monitor emissions of detrimental substances, the Refinery needs approximately 280 million US\$.

II. HIP-PETROCHEMICAL COMPLEX PANČEVO

DESCRIPTION OF ACTIVITIES

HIP-Petrohemija is the biggest Yugoslav producer of plastics and synthetic rubber, and also one of the biggest exporters, mostly to western market (up to USD 300 million a year). Before the bombardment, Petrohemija had been producing over a million tons a year consuming some 670,000 tons of Virgin Naphtha as basic raw material and 150,000 tons of industrial salt (sodium chloride). Realization of designed capacities is 95% on the average with 99% of top quality products.

Basic products	Designed capacity, t/y	Process technology-licence
Ethylene	200 000	Stone Webster, USA
Propylene	85 000	Stone Webster, USA
C4 fraction (up to 60% of Butadiene)	45 000	Stone Webster, USA
Pyrolysis Oil	38 000	Stone Webster, USA
Pyrolysis Gasoline	138 000	Stone Webster, USA
Chlorine*	88 800	Olin Corporation, USA
Sodium Hydroxide (100%)*	100 000	Olin Corporation, USA
Sodium Hypochlorite*	8 000	Olin Corporation, USA
Vinyl Chloride Monomer*	100 000	Stauffer Chem. Co., USA
Ethylene Dichloride*	15 000	Stauffer Chem. Co., USA
Hydrochlorid Acid *	9 600	Lurgi, Germany
Methyl Tertiary Butyl Ether (MTBE)	35 000	Snam Progetti Co., Italy
Raffinate II	22 000	Snam Progetti Co., Italy

* - Considerable or total reduction of production due to bombardment

BASIC DATA OF POLYMERS PLANTS

Polymers	Designed capacity, t/y	Process technology-licence	Designed by
High Density Polyethylene (HDPE)	50 000	Phillips Petroleum Co., USA	Crawford&Russel, USA
Low Density Polyethylene (LDPE)	45 000	National Distillers Co., USA	Foster Wheeler Co., USA
Polyvinyl Chloride (PVC)	34 000	Stauffer Chem. Co., USA	Foster Wheeler Co., USA
Styrene Butadiene Rubber (SBR)	40 000	Bunawerke, Germany	Lurgi, Germany

PROCESSING OF POLYMERS

POLYETHYLENE PIPES

Diameter 20-250 mm
Capacity 5 000 t/y
Gas Pipes up to 4 bar
Water Pipes up to 10 bar

ELECTROFUSION FITTINGS

(couplers, reducers, tees, end caps, tapping tees, branch saddles)

Diameter 20-315 mm
Capacity 300 000 pieces/y

CORRUGATED ELECTRO-INSULATING PIPES

(PVC, PP, PE)

Diameter 16-63 mm
Capacity 250 t/y

PVC AND HDPE BLACK AND COLOURED GRANULATE

Capacity 16 000 t/y PVC
10 000 t/y HDPE

NATO BOMBING AND ITS EFFECTS ON THE ENVIRONMENT

The bombardment on two occasions, on April 15th and April 18th, 1999, disables the operation in VCM, Chlor Alkali(see photo1.and 2.) and PVC polants, and significantly decreased the possibility of capacity utilization in the remaining plants. During the attacks 25 employees of Petrochemical Plant were injured.

The estimation showed that direct and indirect damage amounted to US\$450,900,00. Environmental damage amounts 26,000,000 US\$.

Destroyed products and feedstock in Petrochemical Plant

TYPE	QUANTITY (t)
1,2 Dichloroethane	2300
HCl	600
NaOH	3000
Natriumhypochlorite	40
Mercury	8
Vinylchloride-monomer	450
TOTAL	6398

450t of Vinylchloride-monomer, burned due to the explosion and fire, thus polluting closer and wider surroundings of the Petrochemical Plant. The clouds carrying harmful substances were reported to have reached the neighbouring countries as well.

Due to incomplete combustion, in addition to CO₂, SO₂ and NO_x, great quantities of HCl, soot, partially burnt hydrocarbons, carcinogen aromatic compounds, dioxines, phosgene and other substances, were emitted into the air, jeopardizing and contaminating a wide area, but mostly local population and soil.

It is estimated that a considerable quantity of various, extremely toxic chemicals, crude oil and derivatives was spilled. These, together with solid combustion products and fire-fighting substances, polluted the ground in the Petrochemical Plant. About 170.000 m³ of waste water was discharged into the Danube as an emergency measure, by way of the sewer system and waste water canal. In addition to the spilled crude oil and derivatives, this waste water also contained the following:

- ❑ 1.400 t of 1,2 dichloroethane
- ❑ 600 t of hydrochloric acid
- ❑ 40 t of natriumhypochlorite
- ❑ 3.000 t of natrium hydroxide
- ❑ 0.2 t of mercury

According to the estimates, the total area of the soil in the Petrochemical Plant contaminated by the spilling of crude oil, products, chemicals and mercury is about 60.000 m², with the different depths of pollution depending on the soil composition and the quantity and kind of the spilled substances. Soil thus contaminated must be treated, not only because of the direct danger to the personnel working in the process, but also because of a possible penetration of harmful substances into the groundwater, and jeopardizing the population by way of the food chain. Significant quantities of spilled substances, together with the soil, got into the oily and rainwater sewer, as well as into the primary waste water processing unit (API Separator), which directly jeopardized the quality of water discharged into the Danube. The soil polluted by the spilled mercury and 1,2 dichloroethane is particularly dangerous and it has to be processed before being disposed.

ENVIRONMENTAL POLLUTION

UNEP results of groundwater measurements in the vicinity of VCM unit in Petrochemical Plant of 15 February 2000, given in Table 1, prove the groundwater migration assertion.

Table 1 Content of aromatics, total hydrocarbons, mercury and 1,2 dichloroethane (EDC) in the samples of groundwater in Petrochemical Plant.

Piezo-meter No.	EDC content $\mu\text{g/l}$	Benzene $\mu\text{g/l}$	Toluene $\mu\text{g/l}$	Ethyl-benzene $\mu\text{g/l}$	Xylenes $\mu\text{g/l}$	Mercury $\mu\text{g/l}$	PHCs mg/l
X ₁₋₈	279	9.9	1.8	1.5	1.2	<0.05	2.9
X ₂₋₉	204	15	1.1	2.6	2.8	0.18	0.35
X ₃₋₁₀	118	12	0.9	1.8	1.3	0.06	0.34
B ₅	47.000	105	30	nd	nd	8.1	0.25
B ₆	10.500	nd	nd	nd	nd	87.1	2.55
B ₇	66.600	91	nd	415	280	5.0	3.3
B ₁₁	16.000	7.4	3.8	2.6	3.0	0.06	1.74
B ₁₂	38.000	11	5.2	2.5	2.0	0.52	0.63
B ₁₃	15.100	19	19	1.9	6.9	0.05	1.13
B ₁₉	47.000	2.5	1.6	2.2	0.9	0.05	0.30
B ₂₀	16.200	40	5.8	3.0	3.1	0.45	0.38
B ₂₁	92.600	94	3.0	2.3	2.0	1.53	1.22

nd-not detected

The results show an extremely high content of all the tested contaminants in Petrochemical Plant groundwaters, especially that of 1,2 dichloroethane, for which MPL in drinking water is 3 $\mu\text{g/l}$. It is well known that 1,2 dichloroethane is a carcinogen substance that is easily absorbed into human organism. Considering that it is heavier than water, it easily penetrates through the soil and pollutes groundwater.

Table 2 Results of inspecting the waters from the Danube and waste water canal

Place of sampling	Date of sampling 1999.	1,2 dichloro ethane	PHCs	PAH	LAB	Mercury	
		$\mu\text{g/l}$	$\mu\text{g/l}$	$\mu\text{g/l}$	$\mu\text{g/l}$	$\mu\text{g/l}$	
I-1	28. April	nd	32.1	0.10	<0.1	nd	
I-2		nd	25.2	0.08	<0.1	nd	
II-1		51789000	372412	6.3	<0.1	nd	
II-2		70766000	314582	2.19	<0.1	nd	
III-1		11900	98201.4	1.5	<0.1	nd	
III-2		68000	6435.8	1.3	<0.1	nd	
IV-1		8065000	1285620	10.7	350.2	nd	
IV-2		25511400	1023599	15.1	327.4	nd	
I-1		18. May	nd	19.7	0.04	<0.1	nd
I-2			nd	12.5	0.01	<0.1	nd
II-1	nd		29.8	1.48	12.8	nd	
II-2	nd		32.1	0.47	32.2	nd	
III-1	nd		20.2	0.16	5.1	nd	
III-2	nd		17.5	0.17	7.4	nd	
IV-1			12.7	1197.1	14.1	128.5	Nd

IV-2		32.5	1025.2	10.3	145.1	nd
I-1	1. July	nd	27.8	0.1	<0.1	nd
I-2		nd	29.9	0.09	<0.1	nd
II-1		nd	30.8	0.15	47.9	nd
II-2		nd	25.7	0.12	22.3	nd
III-1		nd	19.8	0.07	13.8	nd
III-2		nd	22.9	0.05	7.5	nd
IV-1		21.5	1471.5	0.66	202.5	nd
IV-2		27.9	1011.8	0.64	259.5	nd
I-1	22. July	nd	6.8	0.03	10.2	nd
I-2		nd	8.1	0.02	5.7	nd
II-1		nd	5.9	0.04	48.9	nd
III-1		nd	3.9	0.05	128.5	nd
IV-1		9.8	110.1	0.09	192.7	nd
IV-2		18.0	658.5	0.12	145.8	nd

I -The Danube upstream of the canal; II –The Danube about 100m downstream of the canal
 III-The Danube 1000 m downstream of the canal; IV-Waste water canal
 1 -0.5 m from the surface; 2 -0.5 m from the bottom; nd-not detected

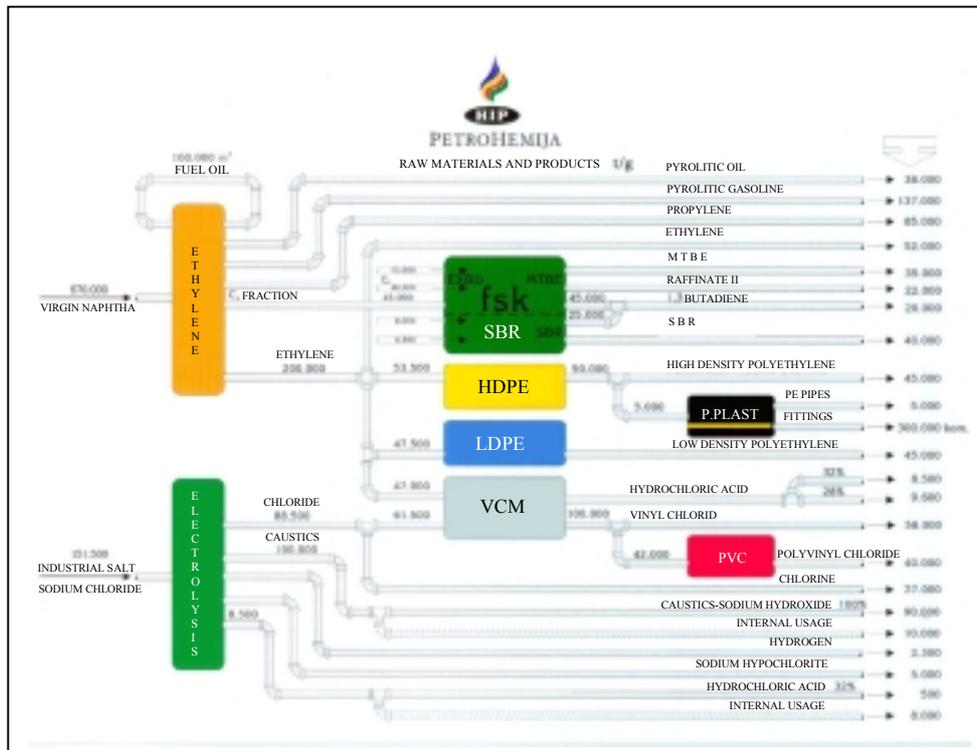


Table 3 Results of the Danube and waste water canal sediment analyses

Place of sampling	Date of sampling 1999.	1,2 dichloro ethane	Toluene	PHCs	LAB	PAH	Mercury
		mg/kg	µg/kg	µg/kg	µg/kg	µg/kg	mg/kg
I	28. April	nd	17.5	387.3	nd	98.2	0.24
II		384.3	283.1	1691.1	nd	9789.2	0.27
III		206.3	133.9	693.4	nd	1228.1	0.16
IV		889.1	836.9	766371	nd	11923	1.68
I	18. May	nd	nd	191.5	nd	120.0	nd
II		1.3		429.5	25	471.7	nd
III		nd		218.9	19.8	130.1	nd
IV		149.8		4792.5	177.7	9831.5	0.62
I	01. July	nd	nd	95.1	19.2	250	nd
II		nd	nd	217.1	118.4	182	nd
III		nd	nd	141.8	102.3	41.8	0.17
IV		195.7	15.2	3127.2	497.8	6742.7	0.66
I	22. July	nd	nd	29.5	2.1	18.2	0.72
II		nd	148.8	114.5	17.3	11.8	11.15
III		nd	nd	55..	14.9	37.2	0.9
IV		nd	nd	10207	2839 1	865.6	3.5

I-The Danube upstream of the canal

II-The Danube 100 m downstream of the canal

III-The Danube 1200 m downstream of the canal

IV-Waste water canal

Based on the results of 18 April 1999, and a very high 1,2 dichloroethane content of 7076 mg/l and 372 mg/l of total hydrocarbons in the Danube water downstream of the canal mouth, as well as a high content of 1,2 dichloroethane and total hydrocarbons in the Danube sediment, it must be concluded that the Danube water has been highly contaminated.

Even if later analyses of the Danube water and sediments showed considerably lower values, it can be seen that waste water canal is still very polluted and that it presents a constant danger to the Danube of further contamination.

ENVIRONMENTAL REMEDIATION

Based on the collected documentation and soil and groundwater samples taken from the field, UNEP experts have prepared a Feasibility Study for the remediation of the contaminated areas, within which there are seven environmental remediation projects for the Petrochemical Plant.

1. **Delimitation of the pollution by EDC and evaluating remediation techniques**
The choice of soil remediation technique in VCM unit shall be performed according to the method applied in a Dutch company AKZO NOBEL VCM PLANT Rotterdam. The method is called "PUMP AND TREAT" The contaminated water is extracted at MPPE (Macro Porous Polymer Extractions). The costs for the preparation of this project amount to 173.000 US\$.

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2. **Remediation of the soil polluted by EDC**
Remediation is performed at VCM unit, in order to prevent further contamination of groundwater.
Costs of preparing this project, along with remediation, amount to 332.000 US\$.
 3. **Remediation of groundwater polluted by EDC**
This remediation is planned to be performed in-situ, in order to prevent contamination of the Danube and surrounding drinking water wells.
Costs of preparing this project, along with remediation, amount to 1.283.000 US\$.
 4. **Monitoring programme of Petrochemical groundwater**
This project includes the measuring programme in the duration of thirty months, and the costs for this project amount to 66.000 US\$.
 5. **Cleaning and remediation of soil and groundwater contaminated by mercury**
Remediation of the soil in chlor-alkali plant, which had been contaminated by mercury, in the first phase implies the removal of the surface layer of soil to the depth of 1 m, into which 7.8 t of mercury had been spilled. This first phase also includes safe dislocation of this soil into the box with impermeable foil (the programme was implemented in cooperation with the humanitarian organization FOCUS, which provided the financial aid). The second phase of this programme consists of removing the mercury from disposed material.
The duration of this project is 8-18 months, while estimated costs amount to 1.919.000 US\$.
 6. **Cleaning and reparation of the water treatment plant**
Reparation of the water treatment plant implies the following:
 - Cleaning and reparation of concrete basins
 - Cleaning and reparation of biofilters and aeration basins (activated sludge)
 - Mechanical equipment reparationThe duration of this project is 4-6 months and estimated costs are 1.568.000 US\$.
 7. **Safety assessment of the sludge dump, recommendations for action and monitoring programme**
The project includes the control of safety measures regarding water treatment sludge dump and the suggestions for further operation, with the programme of groundwater monitoring because of a possible leaking of the disposed material.
The duration of the first part of this project is 6 months, while the planned period for monitoring is two years, and the costs amount to 72.000 US\$.

All the programmes have been included in priority I, except for the programme number 7, which has been ranked as priority II. The financial means necessary for the implementation of the stated projects (without the procurement of the required equipment and devices) are estimated to the total of 5.413.000 US\$.

IMPACTS OF THE SANCTIONS ON REALIZATION OF DEVELOPMENT PROGRAMMES OF PETROHEMIJA AND ON ENVIRONMENT PROTECTION

During several years of isolation of the Federal Republic of Yugoslavia and UN sanctions, Petrohemija was forced to shut down its plants from June 1992 until September 1996. Irreparable damage amounting to hundreds of millions USD was the reason why our

technological improvements, including improvements of environment protection, had not been realized. One of the most important programmes included the conversion of chlorine production process in our Chlor-alkali electrolysis plant. The designed documentation prepared for this purpose assumed total replacement of the technological process with no mercury in the process. We are talking here about the technology offered by COMPRIMO company. This technological process called 'membrane technology' was supposed to be realized by 1996 and the investment would be about USD 100 million. A whole series of modifications intended for environment improvement have not been realized for the same reason.



Photo 1. VCM Plant: heavily damaged VCM storage sphere

Already impoverished Petrohemija had to spend USD 10 million for conservation of the plants during this period of total shut down and necessary overhauling activity before the start up.

The sanctions and bombardment of more than 40% of the capacity, together with the fact that the equipment is more than 20 years old, made Petrohemija ripe for necessary investments intended for the safety of operation and environment protection. Minimum investments required for better environment protection and remediation of already damaged environment amount to ten of millions USD.

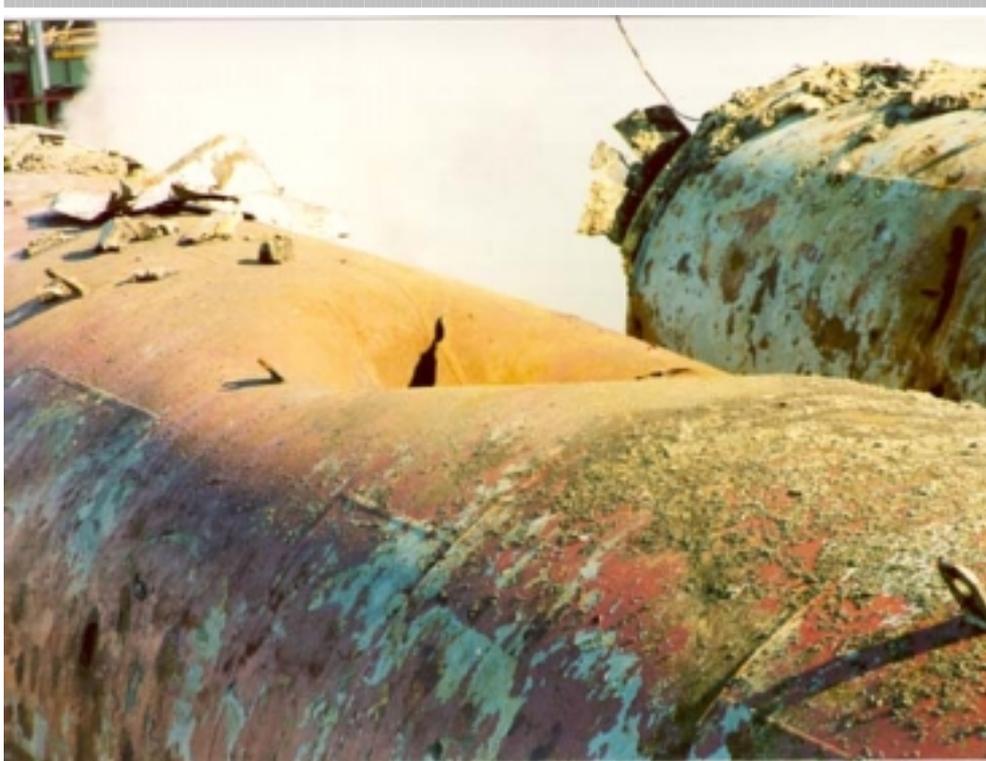


Photo 2. Chlor-Alkaly Plant: destroyed fluid chlorine tank

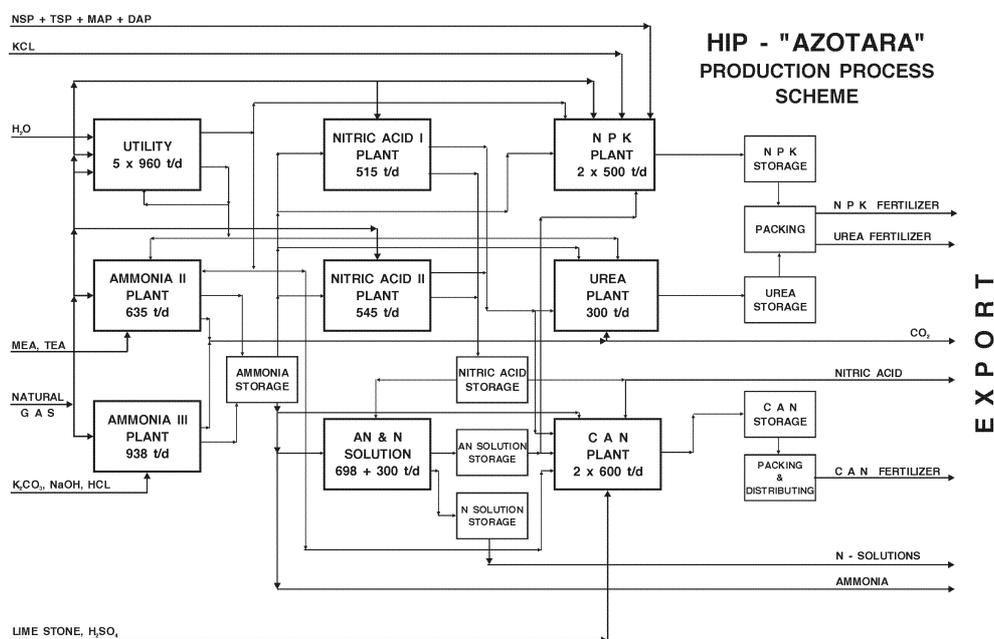
III. HIP AZOTARA

DESCRIPTION OF ACTIVITIES

HIP Azotara Fertilizer Company has already celebrated the 38th anniversary and has grown into an enterprise of approximately 1.800 employees.

The Company became the major national fertilizer producer and the only producer of ammonia in the country. The capacity of the Company plants prior the air raids was as following: 500.000 tons/year of ammonia, 350.000 tons/year of nitric acid, 400.000 tons/year of calcium ammonium nitrate - CAN fertilizer, 400.000 tons/year of the NPK complex fertilizer, 100.000 tons/year of UREA fertilizer, 20.000 tons/year of N - solutions. CAN fertilizer is produced according to the French technology while all the remaining products are made following the US technology.

Table 3 – HIP “AZOTARA” PRODUCTION PROCESS SCHEME



THE EFFECTS OF THE SANCTIONS

The long period of the economic sanctions and the NATO air raids made huge impact to the production of HIP Azotara Fertilizer Company, causing the financial loss and destruction of some of the plants, which prevented the Company from the implementation of the ecology standards and environmental protection.

1. SHORTAGE OF RAW MATERIALS AND PRODUCTION DISRUPTION

a.) Natural gas shortage

Disruption of the production and the irregular supply of natural gas caused technological and economical problems leading to the damages of the equipment and decreased production. Therefore, the expected revenue was never achieved. On the other hand, the increase of the gas consumption per ton of final product produced not only the additional financial expenses, but also the additional pollution to the environment.

Due to the consequences of the sanctions and the NATO air-raids the loss of the Ammonia Plant reached the sum of 2.331.034.200,00 dinars representing 66,95% of the total cumulative loss of HIP Azotara Fertilizer Company amounting 3.481.835.000,00 dinars. Due to the shortage of natural gas, the Utility was often operating on heavy oil, damaging thus the boilers, producing additional expenses and affecting the environment.

**Table 1 – Ammonia Plant, production disruption from
January 1st, 1991. – June 1st, 2001.**

Year	Number of disruptions	Ammonia Plant Total non – working hours	Lost ammonia production (tons)	Lost revenue (din.)
1991.	5	2.775	108.450	195.210.000,00
1992.	8	3.578	139.840	251.712.000,00
1993.	14	4.642	181.425	326.565.000,00
1994.	5	1.527	59.680	107.424.000,00
1995.	5	3.854	150.627	271.128.600,00
1996.	1	744	29.078	52.340.400,00
1997.	3	595	23.255	41.859.000,00
1998.	7	2.682	104.821	188.677.800,00
1999.	1	6.762	264.281	475.705.800,00
2000.	3	5.075	198.348	357.026.400,00
2001.	2	901	35.214	63.385.200,00
TOTAL:	54	33.135	1.295019	2.331.034.200,00

Table 2 – Utility operating on heavy oil.

Year	Heavy oil usage	Steam production (33,34 bar) (t)	Heavy oil consumption (t)
1991.	2	20.631	1.485
1992.	8	14.190	1.022
1993.	23	10.730	772
1994.	4	16.244	1.160
1995.	6	13.888	1.000
1996.	5	4.219	304
1997.	8	63.881	4.599
1998.	7	50.282	3.620
1999.	2	12.039	867
2000.	-	-	-
2001.	-	-	-
TOTAL:	62	206.104	14.838

2. POSTPONED ENVIRONMENTAL POLICY

Since the existing plants and the applied technology dated back to the sixties, it was the obligation of the company following the environmental standards and regulations to produce sanitation programs and environmental plans accordingly. Therefore, the company made the environmental program at the beginning of the nineties.

The objectives of the program were to put into effect the environmental policy which would be tightly connected to the energy saving plans, by implementing the new technologies, including the reconstruction and innovation of the existing production lines.

1. UREA II PLANT

The construction of Urea II Plant started in 1997 and the completion was scheduled for 1999. By commissioning of the modern Urea II Plant, the old one affecting the environment will be closed.

The Urea II Plant was designed according to the Project made by the Dutch Company *Stamicarbon*,

with the capacity of 1.100 t/per day. The applied technological process represents the new, modern generation of urea production. The technology includes CO₂ stripping, total reflux, vacuum packing and water treatment.

The advantages of the new plant are the minimal number of liquid and gas outputs, which are constructed to meet the limit values of emissions, all in accordance to the regulations of the European Fertilizer Manufacturers Association (EFMA).

The existing Urea I Plant dated back to the 1960s and was designed by the American Company *Chemico*. The disadvantage is the total ammonia emission of 2,195 kg/ton of Urea, being 4 times higher than the designed emission limits according to the latest technology standard.

During above mentioned period, although the old plant created ecological problems, these remained unsolved, due to the sanctions, NATO air – raids and the shortage of funds, since the Company was not in position to provide the funds and invest in the construction and completion of the new plant.

During the last 26 months, HIP-Azotara has been running only for 6 months, so it was impossible to obtain the required funds from the current production for the investment in the completion of the new plant. The required amount for the completion of the Urea II Plant is as high as 10 million of US\$.

2. REDUCING THE EMISSION OF THE NITRIC OXIDES NITRIC ACID PLANT

The disadvantage of the existing technology is the high emission of nitric oxides in the air. The feasibility study is prepared covering optional solutions to this problem, each of them including the reconstruction of the existing equipment. The individual stages of reconstruction are accompanied by separate basic designs. For example, the expanding of the absorption tower including the selective reduction is covered by a separate basic design.

According to the mentioned program, the emission of nitric oxides is reduced from 2.200 ppm to 200 ppm.

The realisation of the mentioned program was scheduled for the year 2000 and the Company was prevented from its completion due to the circumstances beyond control, a decade of economic sanctions followed by the NATO air-raids.

The amount of appr. 6 million US\$ is required for the realisation of the program.

3. INTRODUCTION OF NEW TECHNOLOGY CAN PLANT

According to the reconstruction plan, in order to achieve better granulometry, modernization of CAN Plant was planned, referring particularly to the granulation section. Granulae

dry treatment and dust removal including the modern scrubber systems will be introduced to streamline the production.

By the realisation of this program, the dust (PM) and ammonia emission into the atmosphere will be almost completely eliminated and the problem of waste water contamination will be solved.

Financial funds for the realisation of the program reach almost 8 million US\$.

4. SEPARATION OF COOLING, WASTE AND SANITARY WATER AND WASTE WATER TREATMENT

Cooling, technological, atmospheric and sanitary water of the Company are discharged into the same sewage system. The separation of the cooling water from technological water, sanitary and atmospheric contaminated water are planned to be effected, including the construction of the facility for treatment of the contaminated water.

Out of the total water quantity discharged directly into the waste water canal, and further into the river Danube, app. 5%, i.e. 715 m³/h will be directed into the treatment facility.

The contamination of the river Danube will be decreased, simultaneously reducing water consumption and active material consumption from the waste water treatment facility.

Financial funds necessary for the realisation of the program reach almost 12 million US\$ (5 million US\$ for the cooling system and 7 million US\$ for the contaminated waste water).

The realization of the program was already scheduled for the year 2005. According to the financial situation in HIP Azotara, the problem is not likely to be solved in the near future.

NATO AIR RAIDS

HIP-Azotara was targeted on 15th, 16th and 18th April 1999 by four missiles. The air raids destroyed several plants while others remained heavily damaged as following:

Ammonia III Plant	– heavily damaged
Ammonia storage, capacity: 15.000 tons	– heavily damaged
NPK Plant	– destroyed
Utility – heavy oil tank and heavy oil pump	– destroyed

Table 1. – Destroyed final products and raw materials.

Type	Quantity (t)
Ammonia and ammonia water	230
Heavy oil	328
NPK	700
Ammonium sulphate and superphosphate	45
Rubber	10
Others	10

Serious spills of app. 200 tons of ammonia and ammonia water were released into the waste water canal during the period of 72 hours, while a portion of 30 tons of ammonia polluted the air. Some products and raw materials were burnt and polluted the atmosphere. Large quantities of the pollutants were released into the air, ground and water, partially reaching the ground water and wastewater canal after the spells of heavy rain following the targeting. The most severe of the air – pollutions happened on April 18th 1999 when the three Plants located in the industrial area were simultaneously targeted. On April 18th 1999 a missile hit the NPK Plant, which provoked the fire lasting over 6 hrs. Due to the localization of the plant under fire, the firemen were not able to reach the NPK Plant since the VCM storage of the neighboring Petrochemical Plant was targeted simultaneously. As the result, the NPK Plant was destroyed and all the combustible materials burnt in flame. On that occasion, the products of the incomplete combustion (NO_x, SO_x, CO_x, PM, HCl, partially burnt hydrocarbons, phosgene and other pollutants were released into the air. The toxic clouds formed over Pančevo were easily crossed the borders of Yugoslavia, according to the foreign press statements. However, the largest quantities of the pollutants remained in Pančevo area.

Heavy emission of the pollutants occurred after the heavy oil pump was targeted due to the fire, which lasted over 3 hrs, being the consequence of the first NATO attack on HIP Azotara.

On that occasion, app. 328 tons of heavy oil leaked, contaminating app. 2500 m² of the area around the heavy oil pump, while app. 25 tons of heavy oil were burnt. The area of 30.000 m² where the NPK Plant, NPK storage and raw material storage were located was also contaminated.

On the area where the Company is located, hundreds of tons of the burnt wastes remained at the site.

The short – term effects of the air raids causing direct damage to the plant, amount 7,5 million US\$, while the long – term effects remain to be estimated in the coming years.

During the period of the air raids, the monitoring of the soil, water and air – pollution was not performed, since the company laboratory was evacuated.

The representatives of the UNEP (BTF) and FOCUS visited the spot four months following the end of the air raids.

A team of Yugoslav experts joined the UNEP team of experts at the spot taking samples and performing the analyses.

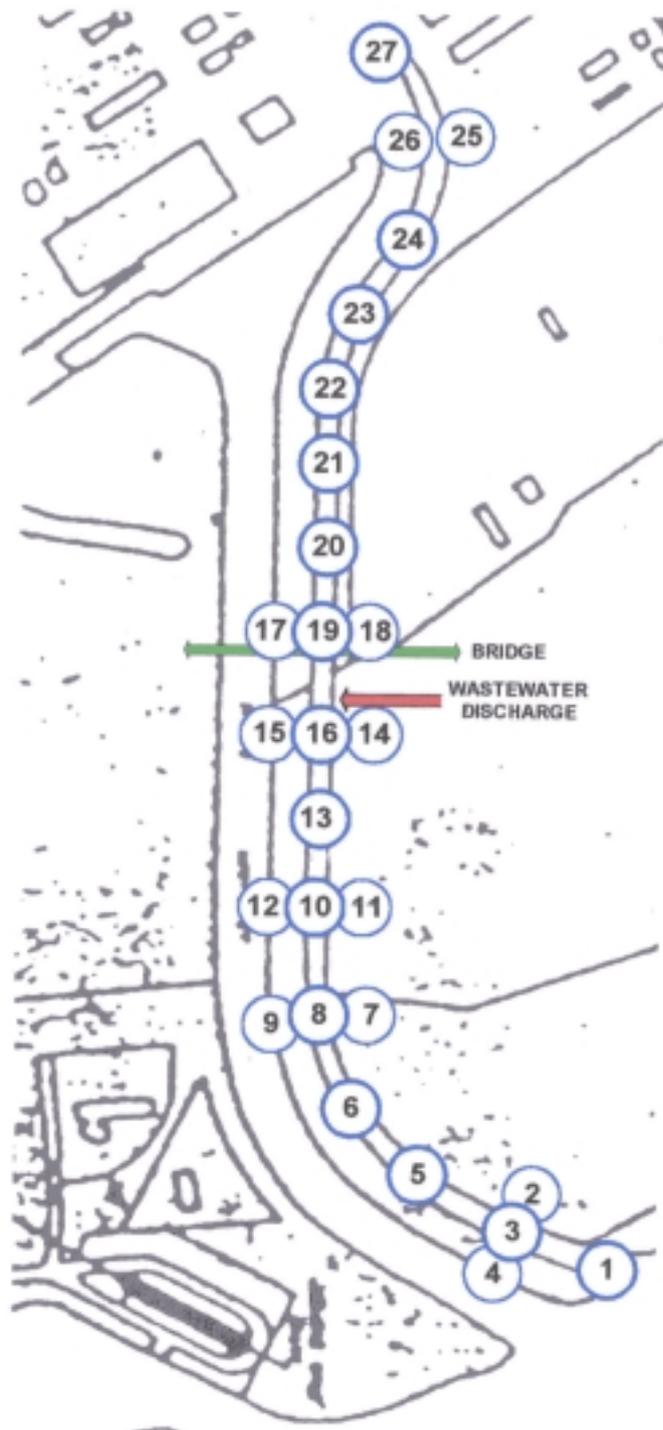
After the analyses were performed, the following was concluded:

The soil inside the Company battery limit was not significantly contaminated, excluding the area of 2.500 m² contaminated with heavy oil in the vicinity of the targeted storage.

The wastewater canal was extremely contaminated as the result of the direct attacks. Large quantities of crude oil and oil derivatives, app. 1400 tons of EDC, 600 tons of HCl, 40 tons of sodium hypochlorite, 3000 tons of sodium hydroxide (NaOH), 0.2 tons of mercury, 200 tons of ammonia water and ammonia and several tons of fertilizers and raw materials contaminated the canal.

The UNEP/BTF team collected the samples of the water from the canal and the sediments at 14 spots.

The analyses proved high concentrations of ethylene dichloride, PAHs, mercury and oil hydrocarbons. The toxic activity of the mentioned substances is well documented. These compounds and elements represent a threat to the river Danube and to the water sources in the area.



PANČEVO WASTEWATER CANAL: SAMPLING SPOTS

CANAL CENTRAL LINE – WATER

On site	Vituki	Length from the mouth (km)	BTEX, µg/l or mg/kg			
			Benzene	Toluene	Ethylbenzene	o-,n-,p-xylene
Pa-Can-W-1	255	0	0.2	0.1	0.2	0.3
Pa-Can-W-3	251	0.1	0.4	0.7	0.2	14.3
Pa-Can-W-5	259	0.2	1.100	29	26	249
Pa-Can-W-6	260	0.3	1.6	1.5	0.3	6.2
Pa-Can-W-8	262	0.4		0.2	0.2	0.6
Pa-Can-W-10	264	0.5	6.9	6.2	0.4	11.1
Pa-Can-W-13	267	0.7	18	5.6	2	67
Pa-Can-W-16	270	0.8	941	530	99	329
Pa-Can-W-9	273	1	1	1.3	2.2	52
Pa-Can-W.20	274	1.1	3	1.7	2.3	46
Pa-Can-W-21	275	1.2	7.9	3.9	2.5	184
Pa-Can-W-22	276	1.3	2	1.4	2.4	84
Pa-Can-W-23	277	1.4	3.1	1.8	2.1	77
Pa-Can-W-27	281	1.8	12	4.5	2.8	4.6
On site	Vituki	Length from the mouth (km)	PHCs mg/l or mg/kg	Mercury µg/l or mg/kg	1,2-dichloroethane µg/l or mg/kg	
Pa-Can-W-1	255	0	4.1	3.31	295	
Pa-Can-W-3	251	0.1	2.4	12.9	949	
Pa-Can-W-5	259	0.2	13.8	166	11.200	
Pa-Can-W-6	260	0.3	2.8	9.19	681	
Pa-Can-W-8	262	0.4	0.74	0.53	297	
Pa-Can-W-10	264	0.5	0.64	0.28	290	
Pa-Can-W-13	267	0.7	1.25	1.11	251	
Pa-Can-W-16	270	0.8	187	0.14	81200	
Pa-Can-W-9	273	1	4.9	1.96	110	
Pa-Can-W.20	274	1.1	15.8	0.56	106	
Pa-Can-W-21	275	1.2	7.7	0.38	105	
Pa-Can-W-22	276	1.3	3.4	0.34	109	
Pa-Can-W-23	277	1.4	17.1	0.5	122	
Pa-Can-W-27	281	1.8	0.99	0.24	1180	

CANAL LEFT BANK – WATER

On site	Vituki	Length from the mouth (km)	BTEX, µg/l or mg/kg			
			Benzene	Toluene	Ethylbenzene	o-,n-,p-xylene
Pa-Can-W-2	256	0.1	nd	0.2	0.2	0.5
Pa-Can-W-7	261	0.1	0.3	0.4	0.2	3.7
Pa-Can-W-14	268	0.3	2.2	0.9	0.2	54
Pa-Can-W-18	272	1	2	1.6	2	47
Pa-Can-W-25	279	1.65	12	1.5	2.2	24
On site	Vituki	Length from the mouth (km)	PHCs** mg/l or mg/kg*	Mercury µg/l or mg/kg	1.2-dichloroethane µg/l or mg/kg	
Pa-Can-W-2	256	0.1	0.65	0.65	274	
Pa-Can-W-7	261	0.1	4.1	8.87	730	
Pa-Can-W-14	268	0.3	2.7	0.49	163	
Pa-Can-W-18	272	1	1.22	0.37	145	
Pa-Can-W-25	279	1.65	0.75	0.23	105	

CANAL RIGHT BANK – WATER

On site	Vituki	Length from the mouth (km)	BTEX, µg/l or mg/kg			
			Benzene	Toluene	Ethylbenzene	o-,n-,p-xylene
Pa-Can-W-4	258	0.1	0	0.1	0.1	0.5
Pa-Can-W-11	265	0.6	30	16	2.7	15.4
Pa-Can-W-12	266	0.6	0.3	0.3	0.2	2.3
Pa-Can-W-15	269	0.8	0.5	0.3	0.2	3.6
Pa-Can-W-17	271	1	2.9	2.5	1.9	58
Pa-Can-W-26	280	1.65	16	4.6	2.8	5.6
On site	Vituki	Length from the mouth (km)	PHCs** mg/l or mg/kg*	Mercury µg/l or mg/kg	1.2-dichloroethane µg/l or mg/kg	
Pa-Can-W-4	258	0.1	3.1	2.15	318	
Pa-Can-W-11	265	0.6	0.88	0.32	283	
Pa-Can-W-12	266	0.6	2.2	0.69	330	
Pa-Can-W-15	269	0.8	9.2	0.68	236	
Pa-Can-W-17	271	1	1.03	0.2	140	
Pa-Can-W-26	280	1.65	0.55	0.2	101	

CANAL CENTRAL LINE – SEDIMENT

On site	Vituki	Length from the mouth (km)	BTEX, µg/l or mg/kg			
			Benzene	Toluene	Ethylbenzene	o-,n-,p-xylene
Pa-Can-S-1	439	0	1520	135	13	475
Pa-Can-S-3	441	0.1	1930	250	31	630
Pa-Can-S-5	443	0.2	2890	52	122	2600
Pa-Can-S-8	446	0.4	1810	260	74	1120
Pa-Can-S-10	448	0.6	5290	1240	488	8340
Pa-Can-S-13	451	0.7	1250	2800	3190	
Pa-Can-S-16	454	0.8	4220	2480	666	2680
Pa-Can-S-19	457	1	778	248	36	1660
Pa-Can-S-20	458	1.1	1760	158	146	2750
Pa-Can-S-21	459	1.2	4990	2700	1220	15000
Pa-Can-S-22	460	1.3	4160	1560	570	14600
Pa-Can-S-23	461	1.4	1360	157	281	5310
Pa-Can-S-24	462	1.5	2080	1160	608	9870
Pa-Can-S-27	465	1.8	744	667	356	3170
On site	Vituki	Length from the mouth (km)	PHCs** mg/l or mg/kg*	Mercury µg/l or mg/kg	1,2-dichloroethane µg/l or mg/kg	
Pa-Can-S-1	439	0	23	4.81	1050	
Pa-Can-S-3	441	0.1	9.7	3.18	3080	
Pa-Can-S-5	443	0.2	18	11.4	2350	
Pa-Can-S-8	446	0.4	14	10.3	63600	
Pa-Can-S-10	448	0.6	54	15.9	12300	
Pa-Can-S-13	451	0.7	59	14.5	577	
Pa-Can-S-16	454	0.8	65	8.45	942	
Pa-Can-S-19	457	1	29	8.5	4890	
Pa-Can-S-20	458	1.1	17	1.35	609	
Pa-Can-S-21	459	1.2	79	7.82	20200	
Pa-Can-S-22	460	1.3	51	8.45	12200	
Pa-Can-S-23	461	1.4	45	2.89	1070	
Pa-Can-S-24	462	1.5	59	2.37	2810	
Pa-Can-S-27	465	1.8	45	5.34	170000	

CANAL LEFT BANK – SEDIMENT

On site	Vituki	Length from the mouth (km)	BTEX, µg/l or mg/kg			
			Benzene	Toluene	Ethylbenzene	o-,n-,p-xylene
Pa-Can-S-2	440	0.1	2350	188	28	265
Pa-Can-S-7	445	0.4	3530	551	167	1260
Pa-Can-S-11	449	0.6	3160	553	174	3190
Pa-Can-S-14	452	0.8	2190	3150	2990	14500
Pa-Can-S-18	456	1	4610	5620	960	17400
Pa-Can-S-25	463	1.65	1070	10500	3690	14600
On site	Vituki	Length from the mouth (km)	PHCs** mg/l or mg/kg*	Mercury µg/l or mg/kg	1.2-dichloroethane µg/l or mg/kg	
Pa-Can-S-2	440	0.1	11 (27)	25.8	2610	
Pa-Can-S-7	445	0.4	13(36)	17.1	12300	
Pa-Can-S-11	449	0.6	31 (73)	22.2	163	
Pa-Can-S-14	452	0.8	94(430)	16.7	302000	
Pa-Can-S-18	456	1	190(330)	20.1	24000	
Pa-Can-S-25	463	1.65	68(230)	17.5	8720	

CANAL RIGHT BANK – SEDIMENT

On site	Vituki	Length from the mouth (km)	BTEX, µg/l or mg/kg			
			Benzene	Toluene	Ethylbenzene	o-,n-,p-xylene
Pa-Can-S-4	442	0.1	2730	214	35	744
Pa-Can-S-9	447	0.4	2550	270	140	1970
Pa-Can-S-12	450	0.6	2940	466	108	4150
Pa-Can-S-15	453	0.8	1740	1460	440	1270
Pa-Can-S-17	455	1	666	76	46	400
Pa-Can-S-26	464	1.65	3030	1490	715	7460
On site	Vituki	Length from the mouth (km)	PHCs** mg/l or mg/kg*	Mercury µg/l or mg/kg	1.2-dichloroethane µg/l or mg/kg	
Pa-Can-S-4	442	0.1	17(54)	15.4	32	
Pa-Can-S-9	447	0.4	36(79)	41.5	168	
Pa-Can-S-12	450	0.6	28(94)	19.5	364	
Pa-Can-S-15	453	0.8	69(270)	15.1	1750	
Pa-Can-S-17	455	1	24(47)	6.19	302	
Pa-Can-S-26	464	1.65	18(34)	4.41	3020	

Based on the survey results of the EDC in the canal, apart from the extremely high concentration of EDC, 3 lens of the free EDC were identified. The first one was located at the beginning of the canal, (at the spot no.27) representing the value of 1/5 of the sediment volume (170.000 mg/kg), followed by 20.200 mg/kg (at the spot no. 21) and the third one of 63.600mg/kg (at the spot no. 8) at app. 400 m from the canal discharge into the river Danube.

The concentration of the mercury proved to be high in the sediment ranging from 1,35 – 25,8 mg/kg. The highest concentration of the mercury was discovered in the sediment sample collected 200 m away from the canal discharge into the river Danube.

The concentration of PAHs in the canal was also very high, as evidenced by the enclosed charts.

ECOLOGICAL HOT SPOT: REMEDIATION PRIORITY PROGRAMS

The remediation of the soil contaminated by heavy oil was performed by HIP-Azotara. The Project was designed and sponsored by the Swiss Relief Disaster Organization-SDR.

The PVC film of 2,5 mm thickness served as the secure barrier for disposal of 600 m³ of contaminated soil equipped by the aeration tubes. SDR invested 90.000 DM in the Project. In spring of the year 2000 the UNEP tem has completed the Feasibility study defining the remediation priority projects for the following hot spots Pančevo, Novi Sad, Kragujevac, Bor.

The wastewater canal of HIP-Azotara was identified in the Feasibility Study as the high priority project and it was named - PA₁₃.

According to the Feasibility Study the wastewater treatment of all the parties involved has to be analyzed, followed by detailed cleaning up of the wastewater canal.

The following options covering the cleaning up were presented.

Option A, although the most adequate, was rejected because of the duration of the proposed remediation period and the high costs.

Option B, was rejected for similar reasons. Option C, consisting of two steps was accepted. Step one- high priority, implementation period: 12 months Step two- medium priority, implementation period: 12 months

The objective of the step one was the protection of the Danube from further contamination, consisting of the construction of the two dams (the first one being at the spot where the canal runs into the Danube, and the second one 50 m downstream the canal from the spot where the waste water from Petrochemical Plant and the Oil Refinery discharge into the canal).

The objective of the step two was the cleaning up of the free EDC from the canal and its transportation to the nearest burner at Dorog, Hungary followed by the complete cleaning

up of the canal and the storage of its content in the improvised container till the final solution is reached.

UNEP estimated that 7.257.000 US\$ are required for the realization of the Project PA₁₃ . We agreed to the complete proposal concerning the wastewater canal remediation presented by

UNEP Feasibility Study, 2000. Today, more than two years after the air raids, the situation concerning the wastewater canal remained unchanged. At the beginning of the year 2001 the team of UNEP experts started with the realization of the Project. Due to the lack of the funds only first step has been completed so far, being the preparation of the technical documentation for the General Project covering the remediation of the wastewater canal. We suggest both steps be regarded as one step and realized consecutively and that funds covering PA₁₃ Project should be provided the soonest possible.