REPORT ON THE DEGRADATION OF THE ENVIRONMENT AT THE SITE OF NIS NOVI SAD OIL REFINERY AND REMEDIATION MEASURES

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ABSTRACT

Before the NATO bombing, Refinery had available 149 tanks for the storage of crude oil, intermediate and final products, additivies etc. All tanks are placed within the impermeable embankments of concrete or soil and connected to the storm and oil sewarage systems which enables the monitoring and control of of oil leakage and storm waste. During the NATO bombing practically all processing units were either destroyed or damaged. The summary of damages inflicted to the processing units is given. During the NATO bombing campaign over 51% of the available storage capacity was destroyed and over 34% of it was severely damaged. A summary of available, destroyed and damaged tank capacities in the NIS Novi Sad Oil Refinery is given.

Key words: degradation of environment, oil pollution, oil refinery, destroying

1.0 LOCATION

NIS Novi Sad Oil Refinery (NIS-RNS) is a part of a large system of NIS Petroleum Industry of Serbia. The company is located in the industrial area of Novi Sad, North IV, covering 1.735 ha gross and ntended for heavy industries such as chemical, petroleum, electrionica, as well as a regional port.
NIS-RNS is located at a 2 km distance from the residential part of Novi Sad, on the left riverbank of the river Danube. Such a location directly affects the residential area Šangaj and the area of drinking water wells "Ratno ostrvo".
In this sense the complex of NIS-RNS covers an area of approximately 156 ha.

1.1 Locations of NIS-RNS and "Ratno ostrvo" drinking water wells

Drinking water source "Ratno ostrvo" is located on the left bank of the Danube, 2 km downstream of the NIS Novi Sad Oil Refinery compound. The Refinery waste water

collection system, sewerage system from Šangaj and outlet of the waste collector "North IV" are all located in the area of drinking water source. It is important to say that drinking water source "Ratno ostrvo" was urbanistically located after the Refinery had been built.

2.0 TECHNICAL INFORMATION

2.1 Layout

NIS-RNS Oil Refinery in Novi Sad (NIS-RNS) is a complex of process units for the production of oil and petroleum products, storage area, transportation and manipulation installations, research and laboratory facilities.

Before the NATO bombing, Refinery had available 149 tanks for the storage of crude oil, intermediate and final products, additivies etc. All tanks are placed within the impermeable embankments of concrete or soil and connected to the storm and oil sewarage systems which enables the monitoring and control of of oil leakage and storm waste.

2.1.1 Effects of NATO bombing campaign upon the process units ans storage area

During the NATO bombing practically all processing units were either destroyed or damaged. The summary of damages inflicted to the processing units is given in the table 2.1.
During the NATO bombing campaign over 51% of the available storage capacity was destroyed and over 34% of it was severely damaged.
Table 2.2. gives a summary of available, destroyed and damaged tank capacities in the NIS Novi Sad Oil Refinery.

Table 2.1. Summary of damages to the NIS RNS processing units

Process units	*Capacity (t/y)*	**% damage**
Fuel Production		
Atmospheric Distillation Unit	500,000	95
Atmospheric Distillation unit with naphtha stabilization U-2100	2,000 000	70
Vacuum Distillation U-2200	1,200 000	60
Naphtha Hydrotreating U-2300	560,000	15
Platforming U-2400	430,000	25
LPG U-2500	60,000	90
HDS middle distillate/VGO U-2600	240 000	5
Lube Oil and Bitumen Production		
Atmospheric Distillation U-100	500,000	10
Vacuum distillation U-200	550,000	60
Bitumen Units U-300	200,000	20
Hydrofinishing U-400	240 000	90
Acid Treatment U-500	89 000	20
Blending	56 000	95

Table 2.2. Summary of destroyed and damaged tank capacities in NIS RNS

Type of fluid	**Volume (m^3)**	**% Destroyed**	**%Damaged**
Crude Oil	195,500	46.8	28.13
LPG	10,000	90	0
Gasolines	80,000	78.7	17.5
Middle Distillates	135,500	64.58	34.69
Fuel Oil	103,000	34.95	39.81
Lube Oil Products	108,000	56.48	41.67
Base Oils	16,100	100	0
Vacuum Residue	20,600	2.91	97.09
Bitumen	8,900	0	100
Total	**677,600**	**51.46**	**34.06**

2.2 Sewarage system

There were three types of sewarage systems in NIS-RNS:

- Closed system for storm sewerage (about 6500 m)
- System for oil waste water (about 13 300 m)
- System for waste sanitary waters (about 1 500 m)

Surface waters are being collected into a closed system of storm sewage in NIS-RNS and through the collector pipe discharged into the Danube.

Foul waters are managed by septic tanks (16) and a smaller quantity is treated on biological filter (4 installed) and drained into the oil sewarage.

NIS-RNS usas physical and chemical methods for the treatment of oil waste waters. (waste water treatment plant and sludge incinerator).

Due to the bombing all three sewarage systems were completely or partially damaged, so in this moment oil and storm waste waters are collected together, without separation. Only sanitary waste water is collected separately.

3.0 CHRONOLOGY OF NATO BOMBING

During the NATO bombing, NIS RNS plants were bombed 12 times with over 250 highly destructive missiles.

3.1 The chronology of burning in NIS Novi Sad Oil Refinery

In regard to the degradation of the environment, potencial ecological catastrophe and environmental impact it would be necessary to point out that the wors effects were inflicted by "carpet bombings" on 1/2 May and 7/8 June. In the first such attack NIS-RNS compound was hit by 108 highly destructive missiles and in the other with 120 missiles. These attacks inflicted both direct and indirect damages. In the course of these attacks the process plants, storage facilities (tanks and protection dikes), as well as the environment protection system and whole infrastructure system (roads, water network, hydrant network, underground installations etc.) were most severly damaged. Large quantites of stored products caught fire and burned (crude oil, intermediate products, final products, chemicals etc. Heavy burning process produced thick black smoke consisted of soot, carbon dioxide, carbon monoxide, sulfur dioxide, nytrogen oxide and products of incomplete combustion of hydrocarbon. The highest portion (67%) of the stored products and chemicals was burning after these two bombing attacks.
It has been estimated that during the NATO bombing campaign upon storage and piping capacities, warehouses and very processing units in NIS-RNS a total amount of 73.770 t of oil and petroleum products was destroyed. According to their basic physical and chemical properties it has been estimated that from this amount, it:

Burned	65. 180 t
Spilled (controlled)	6. 710 t
Spilled through the waste water collector into the Danube	540 t
Recovered from the waste water collector to RNS	130 t
Returned to slop	1.210 t

4.0 ENVIRONMENT PROTECTION SYSTEM IN NIS-RNS

NIS Novi Sad Oil Refinery has been implementing its environment protection system since its foundation 30 years ago trying to follow the latest domestic and international scientific tendencies in the selection of optimal technology and equipment. NIS RNS used to have a reliable system of environmental protection available. According to its definition NIS RNS environment protection system consisted of two basic subsystems:

1. Subsystem for direct environment protection from the adverse effects of processing, manipulative and other activities
2. Subsystem for indirect protection includes the processing units for the production of environmentally friendly fuels (Eco diesel fuel) and biodegradable lube oils.

The table 4.1 gives a representation of basic elements of the above subsystems.

Environment protection system in NIS-RNS was severly damaged by NATO bombing. By general estimation of the damage and based on both domestic and foreign prices of equipment and installation total damage on the environment protection system was calculated as 48 million USD.

The table 4.2 gives the summary of damaged units and % of damage.

Table 4.1. NIS-RNS Environment Protection System

Direct Environment Protection Subsystem
Storm sewerage
Oil sewerage
Waste water treatment system
Acid waste water treatment system
Tank embankment
Eco filling station
An investment project for sludge treatment in the Refinery
Refinery sludge incinerators
Off gas burner system
Tank cooling and fire protection system
Interconnecting pipelines in the Refinery
An information system for the monitoring of process parameters
Indirect Environment Protection System
Blending units for the production of environmentally friendly lubricants
A technological line for the production of Eco Diesel by European Standards

Table 4.2 Summary of damaged units included in the environment protection system.

Unit	% damage
Storm sewerage	70
Oil sewerage	60
Waste water treatment system	55
Acid waste water treatment system	40
Tank embankment	80
Eco filling station	75
Refinery sludge burners	45
Off gas burner system	60
Blending unit for the production of environmentally friendly lubricants	100
Technological line for the production of Eco diesel by European standards	90
Tank cooling and fire protection system	85
Interconnecting pipes in the Refinery	50

The estimation was made by the experts from NIS-RNS.

5.0 DESTRUCTED ENVIRONMENT PROTECTION SYSTEM IN NIS-RNS AND EFFECTS

Assessment of the impact that NATO bombing had on the environment protection system and its destruction was made by the method whose concept is identification of emission sources, contamination sources, monitoring, analysis of all contaminants and proposing of remediation measures according to the concept air-soil-water.

During the bombing campaign about 73.770 t of crude oil and petroleum products was destroyed in a fire (information provided by professional sectors in NIS-RNS which are in charge of regular measuring and recording of the quantities of the crude oil and products in the storage.) About 18 000 t of the mentioned quantity burned at the terminal of the JUNA oil pipeline and about 5 000 of petroleum products burned in the storage of NIS-NAP. It is unquestionable that such incomplete combustion of crude oil and petroleum products caused a great, acute air pollution in the Refinery and in its surroundings. Due to the fire and explosion large amounts of crude oil and petroleum products spilled on the ground thus contaminating a large area of the NIS-RNS site and oil terminal. Furthermore, since the oil sewerage system was destructed and out of operation, it was impossible to transport the spilled quantities to the waste water treatment plant. Uncontrolled leakage of oil through the damaged pipe system contaminated the soil and the groundwater in the area around the waste water collector North IV soil in the area of drinking water wells. Because of the location of the Refinery (on the left bank of the Danube and on the banks of the Danube-Tisza-Danube channel) oil contamination reached the very channel and the Danube. Therefore, as primary contamination we can identify the following cases:

- contamination of waterways
- contamination of air
- contamination of soil by spilling
- contamination of soil and groundwater through the damaged sewerage system

5.1 Air contamination

Air contamination was acute in nature. The presence of major air pollutants within the town area was continually monitored since the beginning of military actions. The analyses were conducted by Public Health Institute of Novi Sad. Points for monitoring of contamination were located on 20 representative localities across the town territory, at an approximately equal distance of about 2 km.

Extra analyses of aerosediment content were conducted from 12 sedimentators located in the settlements around Novi Sad (Kać, Budisava, Kovilj, Titel, Žabalj, Temerin, Futog, Bačka Palanka, Vrbas, Kisač, Bački Petrovac and Bač). The following analyses were conducted: the content of aerosediment, the content f metals in the aerosediment for the town area and suburbs, the analysis of concentrations of soot, sulphurdioxide, nytrogen oxides, carbonmonoxide, the content of carbohydrons and concentration of lead.

5.2 Soil contamination

During the acute, chemical accidents the analysis of the soil quality and monitoring were not performed. After the conflict ended, the experts from the Refinery, with the professional aid and supervision of prof dr Slobodan Sokolović, have started identifying the areas of contamination, types and amounts of spilled crude oil and petroleum products, depths of contaminant migration. Basic lithological content of contaminated soil is given in the table 5.1. The figure 5.1 is a graphical presentation of the localities of the “oil spots”.

The total area covered by contaminated soil is 85 524 m^2, the volume of spilled products is 5 602 t and the volume of contaminated soil (based on the obtained results and assessment) is about 40 000 m^3.

The largest areas of contaminated soil resulted from the spilling and combustion of crude oil (28 780 m^2). The highest content of mineral oil was found in the soil which was contaminated by spilling of diesel oil (about 42 000 mg/kg), and spilling of the mixture of light distillates and motor gasoline (about 8 700 mg/kg). In these areas contaminant migration reached the deepest layers of soil (picture 2). All of these and some other findings were confirmed by the expert mission of UNEP-BTF and FOCUS in their reports.

The Institute "Jaroslav Černi" has, for the purpose of groundwater quality control and monitoring of the contaminant migration and preventive protection of the "Ratno ostrvo" drinking water wells the probe testing of the NIS-RNS site. They drilled 25 probe wells, constructed five new piezometres and determined the concentration of mineral oil according to depth by an analysis of sediment. The results of mineral oil content in the sediment are given in the table 5.2

Table 5.2 The content of mineral oil in sediment

Shallow piezometer	Date of sampling	Total concent. of compounds with CH_x group (µg/l)	Mineral oil concentration (µg/l)	Concent. of other compounds with CH_x group (µg/l)
S-4NIS (0.8 m)	1/sep/99	5340	4700	640
S-4NIS (1.5 m)	1/sep/99	2784	2364	420
S-4NIS (2.9 m)	1/sep/99	900	820	80
S-5NIS (1.9 m)	2/sep/99	45	11	34
S-6NIS (2.1m)	1/sep/99	69	34	35
S-7NIS (2.3m)	8/sep/99	26	8	18
S-7NIS (5.3m)	2/sep/99	57	25	32
S-9NIS (3.6 m)	2/sep/99	44	14	30
S-11NIS (2.1m)	1/sep/99	450	286	164
S-13NIS (2.7 m)	8/sep/99	153	118	35
S-14NIS (1.3 m)	9/sep/99	90	68	22
S-16NIS (2.5 m)	8/sep/99	25	8	17
S-17NIS (0.5 m)	9/sep/99	36	16	20
S-19NIS (1.1m)	1/sep/99	63	26	37
S-20NIS (1.5m)	31/aug/99	965	709	256
S-21NIS (0.2 m)	1/sep/99	29150	21275	7875
S-21NIS (0.5 m)	1/sep/99	305	175	130
S-21NIS (1.7 m)	1/sep/99	72	17	55
G-23, G-22	31/aug/99	66651	42325	24326
S-24NIS (0.5 m)	31/aug/99	38	6	32
S-24NIS (1.4 m)	31/aug/99	33	3	30
S-24NIS (1.8 m)	31/aug/99	47	9	38
S-24NIS (3.8 m)	31/aug/99	26	13	13

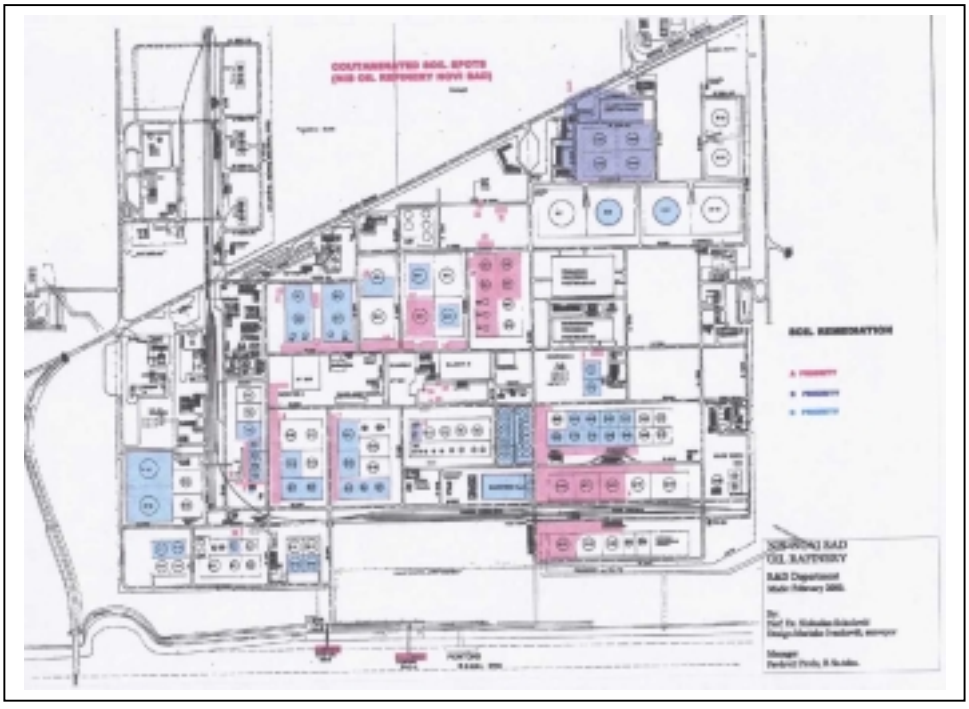
Table5.1. Data characterizing most seriously contaminated areas

Contaminant	Spot N°	Surface area m^2	Volume of spilled product, m^3	Estimated depth of migration, m
Oil	12,20,21,22, 23, 1, 18	28,780	3,794.90	0.8 - 3.0
Vacuum residue	6	1,300	50	0.7
Heavy distillatesi	19	11,427	665	-
Mineral oil	24, 25	420	3.5	1.0
Atmospheric residue	17	5,860	210	0.5-3.0
Straight-run naphta	2	630	0.5	-
Mixture of crude, lightand heavy products	3	5,861	168,3	2,5
Diesel+Slop	4	4,101	338.1	0.3-3.0
Fuel oil + Slop+Straight-run naphta	5	5,150	37.5	3.0
Heavy fuel oil+ Diesel + Kerosene + Straight-run naphtha	7	4,450	8.7	3.5
Crude oil+fuel oil + Diesel + Slop+ Straight-run naphta + Motor gasoline	8	8,200	81.5	2.5
Fuel oil + Diesel + Straight-run naphta + jet fuel+ Motor gasoline	9	1,805	151.5	2
Straight-run naphta + jet fuel + Motor gasoline	10	315	4.0	6.0
Crude oil + Slop	11	300	5.4	-
Crude oil + fuel oil + Slop	13, 14	5,460	66.9	4.5
Crude oil +fuel oil+ heavy distillates + Slop + Mineral oil	15, 16	1,465	16.6	4.0
Total		**85,524**	**5,602.4**	

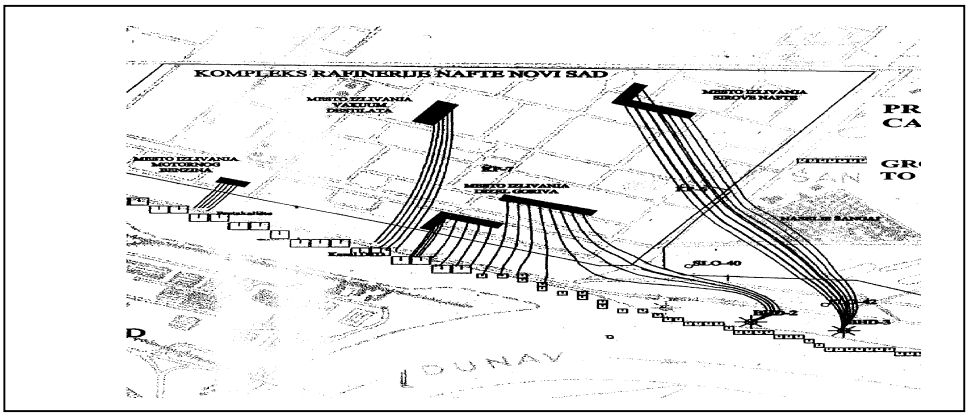
Spot N°	Average content of hydrocarbons mg/kg	Litographic profile	Priority
12,20,21,22, 23, 1, 18	8-300	Artificial sand, dusty sand, fine-grained sand, mud clay, middle-grained sand, clay, quartz sand	**A B C**
6	250	Artificial sand, dusty sand, fine-grained sand, mud clay, middle-grained sand, clay, quartz sand	**B**
19	-	-	**A**
24, 25	-	Artificial sand, dusty sand, fine-grained sand, mud clay, middle-grained sand, clay, quartz sand	**A**
17	300	Artificial sand, dusty sand, fine-grained sand, mud clay, middle-grained sand, clay, quartz sand	**A**
2	-	-	**A**
3	25	Artificial sand, dusty sand, clay, sand, glina	**A**
4	21,275(at 0.3m) - 17 (at 1.7m)	Artificial sand, mud, clay	**A**
5	42,350 (at 0.0m) - 120	Artificial sand, mud, clay, mixed fine-grained sand and middle-grained sand, quartz sand	**A**
7	600	Artificial sand, fine-grained sand, dusty clay, mud, sand	**A**
8	1000-80	Artificial sand, clay, mud clay, sand, mixed middle-grained sand i coarse-grained sand	**A**
9	11 (at 1.9m)	Artificial sand, clay, sand	**A**
10	8,700 (at 0.8 m) - 820 (at 2.9 m)	sand, clay with sand, middle-grained sand	**A**
11	-	-	**A**
13, 14	286 (at 2.1m)	Artificial sand, dusty clay, sand	**A**
15, 16	118 (at 2.7m)	Artificial sand, fine-grained sand, mud, middle-grained sand	**A**

Tabela 5.3. Elements of soil remediation priority assessment

Soil remediation priority			
Element	*A*	*B*	*C*
1. Humanitarian risk assessmenti	Contamination - Novi Sad *city drinking water wells* (60% less water for 300 000 inhabitants) + high health effects on oil refinery workers	Contamination - Novi Sad *city drinking water wells* (60% less water for 300 000 inhabitants) + high health effects on oil refinery workers	Medium health effects on oil refinery workers
2. Spilled oil products	1. Diesel 2. Heavy fuel oil and other products	Crude oil (REB crude oil) and other products	1. Gasoline 2. Diesel 3. Vacuum destillates 4. Straight-run
3. Migration of contaminant flow direction	Drinking water wells	Drinking water wells	Channel Danube-Tisza-Danube
4. Distance from drinking water wells	~ 1000 m	~ 1600 m	~ 50 –300 m



Picture 5.1. Contaminated soil spots



Picture 5.2. Direction of migration flow of spilled oil products in the Refinery working area

5.3 Water contamination (of the Danube and groundwater)

Having in mind the immediate vicinity of the Ratno ostrvo drinking water wells and potential danger that the destroyed environment protection system in NIS-RNS poses, more precisely in order to evaluate the risk to the drinking water source, the monitoring programmes of groundwater and the river Danube have been started at the following locations:

1. The piezometers behind the "Ratno Ostrvo" source were chosen
2. The mud from the Danube bottom
3. The Danube water downstream from the waste and atmospheric water discharge from the waste water collector "North IV"
4. The water from the waste water collector "North IV"
5. The waste water from the waste water collector "North IV"

The following parameters were analyzed (in the period 8 April – 1 June 1999)

Parameter	Range of detected values
Mineral oil content	0,05-430 [g/l]
COD	110-1650 [mgO_2/l]

Based on the COD it has been determined that in the observed period a small amount of spilled oil and petroleum products was in a soluble or disperged phase, i.e. practically the whole existing amount of spilled oil and products formed a stable oil film.
The following parameters were also analyzed in groundwater samples (in the period 12 April – 22 April,1999):

Parameter	Range of detected value
Total amount of organic matter	2,8-24,1 [$KmnO_4$/l]
Mineral oil content	[8-30 mg/l]
Fluorides	ND – 0,30 [mgF/l]

Since, large amounts of fire extinguishing agent were used for the fire extinction and tank cooling interventions in NIS-RNS and that their main component is the fluoride (it is known that 235 t of extract was used) it was necessary to monitor the content of fluoride as well.
In the samples taken from piezometers the highest content of mineral oils was detected in the one from the piezometer located close to the sewerage system. In both piezometers in the Refinery a small content of mineral oil was detected.
In drinking water wells the highest content of oil was detected in the BHD-7 well which is the closest to the waste water collector discharge "North IV" in the period 12-22 April, 1999.
Document:
Report on the analysis of groundwater from Ratno ostrvo, mud from the bottom of the Danube, water in drinking water wells, Danube water and waste water from the collector North IV

PMF – Department of chemical technology and environment protection, Novi Sad

6.0 REPORTS OF INTERNATIONAL HUMANITARIAN ORGANIZATIONS ON THE STATE OF THE ENVIRONMENT AT THE SITE OF NIS-RNS

Two international mission team visited the NIS Novi Sad Oil Refinery immediately after the bombing:

- FOCUS – humanitarian organization including the countries: Greece, Russia, Switzerland and Austria
- UNEP-BTF –United Nations Environmental Protection – Balkan Task Force

Basic task for the memebers of both missions was to by making on-site assessments and taking samples of air, soil and water (groundwater and Danube) prepare their reports on the state of the environment at the site of NIS-RNS.

Simultaneously with them the experts from the Public Health Institute of Novi Sade and Faculty of Technology from Novi Sad were taking samples.

6.1 FOCUS humanitarian mission

The mission took place on 2-3 August 1999

6.1.1 Soil contamination

A Russian laboratory took samplesof soil in NIS-RNS and at the Danube bank, mud from the bottom of the river Danube, groundwater (from piezometers), sample from the waste water separator, sample of water from the Danube and from the driking water wells. Cross analysis were conducted in Switzerland and the results confirmed the correlation of these two laboratories The following was concluded:

1. the chemical analysis confirmes the presence of hydrocarbons in the soil of Refinery area
2. the samples of soil collected in the same place but at different depths (surface, 0.2 m and 0.5 m) show that pollution in total hydrocarbons is localy still in the first 0.2 m of the soil. However, it has to be borne in mind that the sampling was conducted in August 2000 and that current results are quite different.

3. Other samples show that locally contamination is deeper than 1 m and that concentrations of hydrocarbons in these points are 14.2 and 6.1 mg/kg
4. Pyralene and ethylene glycol have been found in the sample taken at the additive and lubricants storage area.
5. Zink was detected in all tested samples (concentration higher than 0.1 mg/kg)
6. Total volume of highly contaminated soil is about 40 000 m^3.

6.1.2 Groundwater contamination

At the time of sampling the depth of groundwater level was 1 m. According to the analysis the water samples from the piezometer KP-7, at 1.5 m depth, is free of hydrocarbon substances. But, a concentration of 6.4 mg/l of oil products was found in the piezometer K-6, near the separator and the treated waste water (after the oil separator) still had a high concentration of oil products (22 mg/l) due to technological problems in the operation of the wastewater treatment plant. The results are very important because this wastewater directly goes in the Danube, through the collector pipe which follows the line of direction of wells.

6.1.3 Air contamination

A lot of chemical substances were detected in the air samples:

Content of petroleum based hydrocarbons	5-220 mg/m^3
Toluol	5-158 mg/m^3
Sulfur hydrogen	5-12 mg/m^3
Hexane	28 mg/m^3
Aceton	22 mg/m^3

6.1.4 Proposals for urgent environmental measures

In their assessment report FOCUS mission has offered a solution for the existing problem of environmental degradation through priorities A and B. Priority A is a monitoring network at the site of NIS-RNS, primarily monitoring of groundwater while priority B is the remediation of soil at the locality of NIS-RNS.

6.2 UNEP-BTF mission

The mission took place on 23 and 24 July 1999.

6.2.1 Soil contamination

The soil samples from the site of NIS-RNS were taken from the depths of 0.8-1.0 m and 0.-01 m and analysed for the content of metals and organic components. The following results were obtained:

Sample No.	Depth	Cd mg/kg	Ni mg/kg	Zn mg/kg	Cu mg/kg	Pb mg/kg	PAH mg/kg	THC mg/kg
1	0,8-1,0	0,25	18	79	15	18	-	-
2	0-0,1	0,13	9,7	35	4,5	9.7	13	2100

6.2.2 Groundwater contamination

In order to make an actual assessment of contamination the experts from this mission took eight samples of groundwater and soil gas. The following results were obtained:

Sample	Content of BTEX µg/l
1. Groundwater sample GW1 – around	5.500
destroyed pipeline (3,5m depth)	510
Soil gas sample (1,1 m depth)	22.000
2. Groundwater sample GW2 (2,5m depth)	100
Soil gas sample (0,5 m depth)	88
3. Groundwater sample GW3 (2,8m depth)	<0,2
Soil gas sample (0,6 m depth)	15
4. Groundwater sample GW2 (3,6m depth)	0,3
Soil gas sample (1,0 m depth)	15
5. Groundwater sample GW2 (1,9m depth)	1
Soil gas sample (0,9 m depth)	

6.2.3 Proposals for urgent environmental measures

It is very important and relevant in this moment to mention that UNEP-BTF mission directs its activities to preparation of the Feasibility study for the solving of the problems in the area of NIS-RNS. Namely, NIS-RNS and Ratno ostrvo drinking water source were identified as one of the four “hot spots” in Yugoslavia. The mentioned study, beside resolving the problem of contamination is to offer the means of financing, for the purpose of eliminating possible humanitarian catastrophe.
Tabular representation of results obtained by these two missions is given in the Enclosure 1.

7.0 REMEDIATION MEASURES OF THE ENVIRONMENTAL PROTECTION SYSTEM IN NIS-RNS

NIS-Novi Sad Oil Refinery is a"hot spot" representing a direct humanitarian threat for the citizens of Novi Sad (cca 400 000) and surrounding settelements for the immediate vicinity of the Ratno ostrvo drinking water source and its potential contamination could hinder the drinking water supply of Novi Sad citizens (reduction for over 60%). It is necessary to take urgent measures in order to permanently remediate and revitalize this area.
Reparation of damaged and destroyed process units is at this moment a task of the highest priority for NIS-RNS-RNS. Fully conscious of the fact that a new start of production also requires an active role and engagement of the environment protection system the reparation of this system was given the high priority as well.
For the reparation to be successful it is necessary to install an integral monitoring system, remediate the contaminated soil, repair and restore the operation of the oil and storm sewerage system and API separators.

7.1 Setting an integral monitoring system

7.1.1 Air quality monitoring

NIS-RNS has got an air quality monitoring system installe. This system comprises measuring of immissions of major contaminants at four localities in the Refinery area. The system continually monitors the immision of nine major contaminants (table 7.1.)

Table 7.1. NIS-RNS – elements of the monitoring system of the contaminant immision

Contaminant	Measuring Frequency	Locality number
Sedimentary substa. with metal content	Continually	4
Soot content	Continually	4
SO_2 content	Continually	4
NO_x content	Continually	4
O_3 content	Continually	1
CO content	4 times a month	1
Lead content	4 times a month	1
Microclimatic measurements	4 times a month	1
Carbohydrons	4 times a month	1

7.1.1 Soil quality monitoring

Table 7.2. NIS-RNS – elements of the soil monitoring system

Parameter	Locality number
Total content of organic matter	8
BTEX content	8
PAH content	8
NSO compounds content	8
Heavy metals content	8

7.1.1 Groundwater quality monitoring

Table7.3. NIS-RNS – elements of the groundwater monitoring system

Parameter	Piezometer number
Total organic matter content	10
Alkaline content	10
Aromatics content	10
NSO compounds content	10
Heavy metals content	10

7.2. Remediation of Contaminated Soil

Contamination of soil by oil and oil products threatens the quality of groundwater, but also the quality of the working environment of all employees and therefore their overall health. Firstly, because of the continuous penetration of contaminants deeper into the ground which brings it into the contact with groundwater which are, as already mentioned, shallow. The other reason is a permanent evaporation into the atmosphere. The project of remediation will develop through the following phases:

1. **Identification of contaminated soil areas in NIS-RNS**
2. **Detailed identification of the type and level of contamination (for each locality)**
3. **Identification of the type and amount of soil (polluted soil volume) for each locality**
4. **Selection of the a locality for deposition of the contaminated soil**

5. **Specification of procedure and costs of mechanical treatment (removal) of contaminated soil**
6. **Specification of procedure and costs of soil cultivation after mechanical treatment**
7. **Selection of technological procedure for the treatment of contaminated soil in the waste depot**
8. **Specification of costs of the selected technological procedure for the treatment of contaminated soil in a waste depot**
9. **Selection and setting of the monitoring system for the quality of cultivated and technologically processed soil**
10. **Specification of costs for the monitoring system**
11. **Concluding remarks**

8.0 PROPOSED MEASURES OF REMEDIATION FOR THE HOT SPOT NOVI SAD – NIS-RNS

Contamination of soil by oil and oil products threatens the quality of groundwater, but also the quality of the working environment of all employees and therefore their overall health. Firstly, because of the continuous penetration of contaminants deeper into the ground which brings it into the contact with groundwater which are, as already mentioned, shallow. The other reason is a permanent evaporation into the atmosphere.

The Refinery employees, together with the experts from the Faculty of Technology from Novi Sad, started to take preliminary activities regarding such a serious task immediately after the bombing. Due to their great efforts, in the course of and after the bombing potential consequences were significantly mitigated. The very fact that over 1000 t of oil and products was returned from the collector to the slop speaks for itself.

Recent activities of remediation and reparation of damage caused by the bombing in NIS-RNS-RNS have been directed only to tackle the most urgent problems. Primarily they concerned the restoration of production by revitalized and after bombing reactivated production facilities. The activities include the reparation of the part of the oil sewerage system, reparation of damage on the wastewater treatment plant, installation of the monitoring system in the immediate vicinity of the restored production units by which the assessment of the influence of the contaminants upon the health of the workers is made. Large amounts contaminated soil have been collected and deposited into an undamaged, concreated tank dike area which is through the system of oil sewerage connected to the waste water treatment plant.

In cooperation with the experts of UNEP-BTF the Feasibility Study has been prepared which anticipates for all the activities directed towards the remediation of the environment and clean-up of Novi Sad and NIS-RNS as one of theforu "hot spots" to develop through the following project tasks:

1. Remediation of free phase oil on the groundwater table.
2. Preventing oil contaminated groundwater at the oil refinery to reach the Danube river and thereby the infiltration galleries through the southern border of the oil refinery (Contaminated groundwater at the southernborder)
3. Preventing oil contaminated groundwater at the oil refinery to reach the infiltration galleries through the eastern border of the oil refinery (Contaminated groundwater at the eastern border)
4. Groundwater monitoring programme on the refinery.
5. Groundwater monitoring programme outside therefinery

6. Remediation of highly contaminated soil
7. Repair of the pipelines system for oil-wastewater

Estimated cost for the proposed measures and projects is around 7 mil USD. Based on the defined parameteres and present situation three levels of priority for the remediation of contaminated soil at the locality of NIS-RNS – table 5.
According to the results of this study the following measures of soil remediation have been proposed:

1. Bioremediation of the soil with the high content of mineral oil (33 000 m^3)
2. Thermal treatment of the soil with the highest content of mineral oil (about 3 700 m^3)

9.0 COST OF REMEDIATION AND REVITALISATION OF DAMAGED ENVIRONMENT PROTECTION SYSTEM IN NIS-RNS

Unit	% damage	Mil. USD (estimated)
Atmospheric sewerage	70	2
Oil sewerage	60	3
Waste water treatment system	55	1
Acid waste water treatment system	40	1
An investment project for sludge treatment in the Refinery	10	3
Refinery sludge burners	45	1
Fuel gas burner system	60	3
Tank cooling and fire protection system	85	1.5
Interconnecting pipes in the Refinery	50	2.5
TOTAL	**18 MIL. USD**	

10.0 RECONSTRUCTION OF DESTROYED FACILITIES OF NIS-RNS ENVIRONMENT PROTECTION SYSTEM

Unit	% damage	Mil. USD (estimated)
Eco filling station	75	5
Blending unit for the production of environmentally friendly lubricants	100	10
Technological line for the production of Eco diesel by European standards	90	8
TOTAL	**30 Mil. USD**	

11.0 SUMMARY SPECIFICATION OF COSTS FOR THE REVITALISATION AND RECONSTRUCTION OF THE NIS-RNS ENVIRONMENT PROTECTION SYSTEM

SPECIFICATION OF COSTS	Mil. USD
REVITALISATION OF DAMAGED FACILITIES OF NIS-RNS ENVIRONMENT PROTECTION SYSTEM	18
RECONSTRUCTION OF DESTROYED FACILITIES OF NIS-RNS ENVIRONMENT PROTECTION SYSTEM	30
MECHANICAL REMEDIATION AND CULTIVATION OF CONTAMINATED SOIL	11
CHEMICAL PROCESSING (SOLIDIFICATION) OF POLLUTED SOIL	4.5
TOTAL	**63.5**