

# ENVIRONMENTAL AUDIT OF THE SITES IMPACTED BY THE “PROBO KOALA” TOXIC WASTE DUMPING IN ABIDJAN, CÔTE D’IVOIRE

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This series of fact sheets was prepared as part of UN Environment's environmental audit of the sites impacted by the “Probo Koala” toxic waste dumping in Abidjan, Côte d'Ivoire. The fact sheets provide complete analysis results, observations and the recommendations for each of the sampling sites. They should be read in conjunction with the full assessment report, available at: [www.unep.org/CotedIvoire](http://www.unep.org/CotedIvoire)



## Site Description

Site name: MACA 3

UN Environment site reference no: 7



## Spill History

Wastes from the Probo Koala are reported to have been dumped onto the roadside at this site located approximately 1 km from Site 6 (MACA 2) on the busy Yopougon-Agboville road. The liquid wastes flowed down the steep, heavily vegetated, embankment into the Banco Forest, a national park. Potentially contaminated material was excavated by Trédi for off-site treatment in 2006-2007, and the resulting void back-filled with clean soil.

## Approach

Four soil samples were collected from the base of a deep depression adjacent to the road, where the spill is reported to have flowed under the road through a culvert. The following samples were obtained:

- One 1 m-depth sample taken in close proximity to the discharge point of the culvert;
- A second 1 m-depth sample taken approximately 10 m away from the culvert; and
- Two composite surface (0-20 cm) samples.

In addition, one air sample, one groundwater sample, one sediment sample, and one sample of comestible vegetation (cassava) were collected at the site.

## Assessment Criteria

Based on the different analyses of the chemical composition of the samples taken onboard the Probo Koala in 2006, as well as those undertaken on samples collected on the dumping sites, UN Environment considered the following groups as the key contaminants of interest for the audit:

- Petroleum hydrocarbons;
- Sulfur compounds; and
- Heavy metals.

The speciation of contaminants to be analyzed within the above three groups was primarily determined by what was present in the Probo Koala waste as well as the environmental standards set by the Government of Côte d'Ivoire for clean-up. In addition, the impact of high levels of sodium hydroxide was measured through the pH value of the soil.

The results obtained from the analyses of **soil** samples were screened according to the following process:

1. Findings were first compared with relevant national standards. In this case, results for soil from all the sites where Probo Koala wastes were dumped and which had undergone remediation were compared with the environmental standards set by the Government of Côte d'Ivoire for clean-up operations conducted by Biogénie at Alépé. If the values obtained were lower than the standards set by the Government, UN Environment considered that no additional clean-up intervention was necessary on the site.
2. If laboratory results for a given parameter showed values exceeding the clean-up standards set by the Government or contractor, results were then compared with the internationally recognized Dutch soil remediation standards (intervention values) to see if further immediate action was needed from an environmental point of view. Dutch standards have been in existence for over 30 years and are used as a basis for contaminated site assessment and clean-up in many parts of the world, when local standards are not available. For most parameters of analysis, however, the Government's clean-up standard was more stringent than the Dutch values.

- Results were also compared with the control sites to see if the observed pollution was also present in the background.

Laboratory analysis results for **sediment** were compared against Dutch soil remediation standards (intervention values).

For **air** quality analysis, for which no national standards exist in Côte d'Ivoire, the approach taken was to compare air quality results from the affected sites with Control Site 21.

Three key sets of parameters were analyzed for groundwater samples, which together would constitute a theoretical "fingerprint" of the Probo Koala wastes: (i) sulfur; (ii) phenols; and (iii) hydrocarbons. In addition, a number of heavy metals that were included in the Government's contract for soil clean-up were also analyzed. Results for **groundwater** quality were compared against control site values (Site 19 at Anyama) and, in the absence of national standards for water quality, Dutch intervention values.

**Fruit and vegetable** samples were tested using similar protocols as those used for analysis of soil and water samples. In the absence of national food quality standards, the European Commission's maximum levels of certain contaminants in food stuffs (EC regulation 1881/2006) are used for comparison. It should be noted that as it was found that there were interferences from naturally occurring substances with the hydrocarbon analyses, the analytical results relating to hydrocarbons were discarded.

## Laboratory Analysis Findings

Soil Parameters (mg/kg)	Site 7 MACA 3				Government standard (mg/kg)
	1 m	1 m	0-20 cm	0-20 cm	
Total Hy C5-C44	30.1	15.2	75.3	77.7	1,000
Benzene	< 0.009	< 0.009	< 0.009	< 0.009	1
Ethylbenzene	< 0.003	< 0.003	< 0.003	< 0.003	25
Toluene	< 0.002	< 0.002	< 0.002	< 0.002	5
Xylene	< 0.009	< 0.009	< 0.009	< 0.009	5
Total sulfur (%)	< 0.02	< 0.02	< 0.02	< 0.02	10
Pb	11	7.1	9.4	11	400
Cd	0.19	0.14	0.13	0.12	20
As	4	2.9	2.3	3.8	37
Cr	48	37	31	56	130
Ni	4.9	3.2	2.9	5.7	140
Co	2	0.61	0.94	2	240
Hg	0.059	0.036	0.040	0.064	7
Cu	9.1	4.5	7.9	8.4	190
Zn	140	10	24	130	9,000
pH	4.54	4.15	6.7	4.38	

Air		Site 7	Control site 21
Parameters/units		MACA 3	Agboville
Dimethyl sulfide	ppm v/v	< 0.1	< 0.1
Ethyl mercaptan	ppm v/v	< 0.1	< 0.1
Methyl ethyl sulfide	ppm v/v	< 0.1	< 0.1
Carbonyl sulfide	ppm v/v	< 0.1	< 0.1
Tertiary butyl mercaptan	ppm v/v	< 0.1	< 0.1
Hydrogen sulfide	ppm v/v	< 0.1	< 0.1
Methyl tert-butyl ether	µg/m3	ND	ND
Benzene	µg/m3	ND	ND
Toluene	µg/m3	ND	ND
Ethylbenzene	µg/m3	ND	ND
Xylene	µg/m3	ND	ND
Naphthalene	µg/m3	ND	ND
TPH (C4-C6)	µg/m3	ND	10
TPH (C6-C8)	µg/m3	31	20
TPH (C8-C10)	µg/m3	35	35
TPH (C10-C12)	µg/m3	31	53
TPH (C4-C12)	µg/m3	16	120
Aliphatic (C4-C6)	µg/m3	110	ND
Aliphatic (C6-C8)	µg/m3	31	17
Aliphatic (C8-C10)	µg/m3	30	31
Aliphatic (C10-C12)	µg/m3	21	53
Aromatic (EC5-EC7)	µg/m3	ND	ND
Aromatic (EC7-EC8)	µg/m3	ND	ND
Aromatic (EC8-EC10)	µg/m3	ND	ND
Aromatic (EC10-EC12)	µg/m3	ND	ND

Groundwater Parameters (µg/l)	Site 7 MACA 3	Control site 19 Anyama	Dutch intervention values (µg/l)
	Private well 20 m	Borehole	
Total Hy C5-35	< 10	< 10	600,000
Benzene	< 7	< 7	30
Ethylbenzene	< 5	< 5	1,000
Toluene	< 4	< 4	150
Xylene	< 11	< 11	70
Free sulfur	< 50	< 50	-
Pb	9.9	< 0.25	75
Cd	< 0.25	< 0.25	6
As	3.8	< 0.25	60
Cr	36	0.41	30
Ni	4.5	1.5	75
Co	0.89	1.4	100
Hg	< 0.25	< 0.25	0.3
Cu	6.3	1.8	75
Zn	62	5.4	800

Sediment Parameters (mg/kg)	Site 7 MACA 3	Dutch intervention values (mg/kg)
	Drain pipe	
Total Hy C5-C44	4.92	5,000
Benzene	< 0.009	1.1
Ethylbenzene	< 0.003	110
Toluene	< 0.002	32
Xylene	< 0.009	17
Total sulfur (%)	< 0.02	-
Pb	9.5	530
Cd	< 0.1	13
As	2.4	76
Cr	30	180
Ni	2.8	100
Co	0.73	190
Hg	0.03	36
Cu	7.8	190
Zn	17	720

Fruit and vegetable Parameters (mg/kg)	Site 7 MACA 3	Control site 21 Agboville	EC regulation (mg/kg)
	Sweet potato	Pomegranate	
Total sulfur (%)	0.0943	0.0547	
PAH	< 0.118	< 0.118	
Pb	< 0.7	< 0.7	0.1
Cd	< 0.02	< 0.02	0.1
As	< 0.6	< 0.6	
Cr	< 0.9	1.62	
Ni	0.234	0.82	
Co	< 0.1	0.149	
Hg	< 0.14	< 0.14	
Cu	2.67	3.85	
Zn	11.4	22.9	

## Conclusions and Recommendations

The laboratory results show that the current concentrations of the contaminants of concern in soil are all below the standards set by the Government of Côte d'Ivoire for clean-up. Likewise, hydrocarbon levels in the sample analysed are well below Dutch intervention values. Furthermore, the pH values are not in the caustic range (9 or above), demonstrating that the impact of the disposal of caustic substances can no longer be detected. No further action is therefore needed on this site to remediate the soil impacts of the 2006 toxic waste dumping from the Probo Koala.

The results for sediment quality analysis indicate that hydrocarbon and heavy metal levels in the sample analyzed are well below Dutch intervention standards.

The results of the air quality analysis can be summarized as follows:

- Mercaptans, hydrogen sulfide and related components cannot be detected in this site, nor the control site. This is significant considering that the key odorants in the Probo Koala wastes were most likely hydrogen sulfide and mercaptans.
- Concentrations of the various analytes at the affected site are comparable to the concentrations found at the control site.

Two observations can be made regarding groundwater quality for this site:

- Samples collected at the site do not show the combined presence of sulfur and hydrocarbons, which could have been indicative of leachate contamination from sites impacted by the Probo Koala wastes.



- Chromium concentrations, however, exceed Dutch intervention values and are above background levels in the sample taken from a private well near the dumping site. As conventional treatment systems for drinking water do not remove heavy metals, their concentrations in drinking water supplies should be monitored regularly, and treatment such as carbon filtration should be introduced if needed.

Based on the fruit and vegetable results, the following observations can be made:

- All samples, including the pomegranate sample from Control Site 21 at Agboville, show the presence of various analytes and heavy metals. Fruits and vegetables naturally accumulate heavy metals from the soil. As most of the heavy metals are essential to human health in small quantities, their uptake through fruits and vegetables is not considered to be a risk.
- The EC standard for lead is below the detection limit of the laboratory analyses. However, considering that all samples, including control samples, show comparable heavy metal values, these results are not considered to warrant further follow up.

## Site Photos



Source: UN Environment





Source: UN Environment



Source: UN Environment





Source: UN Environment