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Evaluation of sanitation risk of toxic waste contaminated soils

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Abstract

This work aims to understand the sanitation risk of toxic waste on tropical contaminated soils. The Ivorian Antipollution Center discovered 540 m3 of the toxic waste from Probo Koala boat in 21 August, 2006. These toxic wastes have been seen in 13 zones of the Abidjan district: Akouédo, Abobo, AboboAlépé road (DJIBI village), civile prison road (MACA), industrial zone of Koumassi, Port-Bouët - Vridi CAP Logistic (Rue Saint-Sylvestre) … This situation caused a socio-political crisis and generated the death of many people. In the aim to know the environmental impact and health risk assessment of toxics waste, of these contaminated soils in Abidjan district (Ivory Coast) the samples of these toxic wastes have been sent to analyses in France. This analyse show that the principal compound of thes toxic waste is Polycyclics Aromatics Hydrocarbons (PAH), Volatile Aromatics Compound (VAC), Mercaptans and sulfurs molecules, Heavy metal, sulfur, Aliphatic Hydrocarbons, Linear hydrocarbons and Total Petroleum Hydrocarbons (TPH). As these compounds present carcinogenic, toxic, and mutagenic properties, some of them were classified as priority pollutants by the US-EPA (Keith and Telliard 1979). In environment, the toxic waste causes the contamination of sols, water, air around the world (US-EPA, 1999). In this work, we want to present to you the risk of toxics waste on the health of people and the environment in the district of Abidjan.

Keywords: Toxic waste; Contaminated soil; Health risk assessment; Sanitation; Environment

1. Introduction

This work aims at identifying, characterizing and sources of risk assessments of contaminated soils in district of Abidjan. In 21 Auguste 2006, 540 m3 of toxics waste have been discovered in 13 zones of Abidjan district in Ivory Coast. The pollutes compounds toxic waste were discharge in Abidjan distric made 30 000 cases of intoxication and the death of one hundred people. The sanitary studies to the Sites and Soils Polluted need the numerical quantities of data and parameters of one situation to compare to existing norms. Sampling of soil gases, surface and ground waters, indoor air, in situ soil analyses, measurement of petroleum hydrocarbon as well as ingestion rate of soil and home-produced vegetables was relise. Exposure frequency and duration show the lowest magnitude (together with human exposure factors (food ingestion, body weight, and inhalation rate) and sample management (with adherence to standards). As regards human factors (food ingestion, body weight and inhalation rate, exposure duration and frequency), preference

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should be given to the data from recent and local surveys. In our analyses we use European Commission, ECB (2003), US-EPA (2001; 2004; 2007a; 2007b, ECHA (2010; 2011) and many other norms data of health risk assessment.

2. Experimental

2.1. Samples

This study concerns the 13 toxic waste zones contaminated in "south" of Ivory Coast, which are located in the Abidjan district. The samples selected have been collected in these zones. These geographic positions are given in Table 1.

Table 1 The geographic position of 13 contaminated toxics wastes zones

Zone	Unloading géographique position
Cocody :Akouédo	-AkouédoI :N 05°21.429' - W 03°56.095' -AkouédoII :N 05°21.077' - W 03°56.206' -AkouédoIII :N 05°21.425' - W 03°56.028'
Abobo	-Abobo (Coco services) : N 05°24.092' - W 04°01.167' -Abobo Sagbé : N 05°24.409' - W 04°01.593' -Plateau Dodui I : N 05°23.403' - W 04°00.367'
AboboAlépé Road (DJIBI Village)	-Alépé 1 : N 05°27.373' - W 03°58.344' -Alépé 2 : N 05°27.572' - W 03°58.280'
Yopougon : Civile Prison Road (MACA)	-MACA I : N 05°23.354' - W 04°04.710' -MACA II : N 05°24.811' - W 04°04.674' -MACA III : N 05°25.309' - W 04°04.405'
Koumassi	-Koumassi Industrial Zone : N 05°17.547' - W 03°56.783'
Port-Bouet	-Vridi CAP Logistic : N 05°15.832' - W 03°59.980'

2.2. Analytical

2.2.1. Extraction-fractionation

The toxic waste fraction was recovered by soxhlet extraction in chloroform for 48 h. The aliphatic, aromatic and polar fractions were isolated by liquid chromatography on a silica column with successive elution by pentane and by a mixture of pentane and dichloromethane. Polar compound was recovered with methanol/dichloromethane. After each step, the recovered fractions were weighed and their mass difference was calculated.

2.2.2. Gas chromatography-mass spectrometry

Aliphatic and aromatic hydrocarbons as well as polar compounds were analyzed by gas chromatography–mass spectrometry (GC–MS) (HP 5890 Series II GC coupled to a HP 5971 mass spectrometer), using an on-column injector, a 60 m DB-5 J&W, 0.25 mm i.d. and a 0.1 mm film fused silica column. The temperature program was 40–3008C at 38C/min followed by an isothermal stage at 3008 °C for 15 min (constant helium flow of 1 ml/min). Because of the presence of carboxylicacids in the polar fractions, silylation using BSTFA 1 TMCS (99/1) was carried out in order to improve the chromatographic resolution [40,41] (Biache and al., 2014a). A small aliquot of sample was dissolved with the derivative solution at a 4 mg/ml concentration and was treated for 15 min at 508 °C. One microliter of the solution was then directly injected into the gas chromatograph (Biache and al., 2014b).

We also used geochemical analytic technical like GC-FID, ICPMS in this study. The detail of all of analyses methods are shown in table 2. The identification of the dangers of the contaminated zone permitted as to specify the parameters to analyze. So, according to the sensitive zones, these chemical parameters were followings.

Table 2 Parameters and analyticals methods

Parameters	Norm	Technical	Laboratory
Benzene and aromatics (VAC -BTEX)	NF ISO 11423-1(#)	GC-MS	Wessling Lyon (F)
Volatile Halogenated Hydrocarbons Compounds (VHOC) on water	NF EN ISO 10301(#)	GC-MS	Wessling Lyon (F)
Polycyclics Aromatics Hydrocarbons (HAP)	Internal method HAP-PCB adapted de NF T90-115(#)	GC-MS GC-FID	Wessling Lyon (F)
Hydrocarbons Idication (GC) on water / leached (HCT)	NF EN ISO 9377-2(A)	GC-FID	Wessling Lyon (F)
Metals / Elements on water / leached	DIN EN ISO 11885 / DIN EN ISO 17294-2(A)	(ICP-MS)	Wessling Altenberge (D)
Metals on water / leached	NF EN ISO 17294-2(#)	(ICP-MS)	Wessling Lyon (F)
Metals on water / leached (ICP-MS)	NF EN ISO 17294-2(#)	(ICP-MS)	Wessling Lyon (F)
Mercaptans on water	WEX 100	(ICP-MS)	Partner Laboratory

3. Results and Discussion

We show here some of our result which are used to determine the health risk assessment. It is very important for us to note that the concentations of the different elements present in the table of the results of soils, of the superficial and underground waters and air analyses are the concentrations gotten after the depollution proccess of toxic waste sites and soils affected.

Table 3 analyses of soils and strong matters

Chemical element	Unit	Abobo 01	Maca 01	Maca 02	Akouedo 01	Akouedo 02	Dokui 01	Dokui 02	Dokui 03	TM	Gouv Norm (mg/kg)
Global parameters / Indication											
Indicehydrocarbure C10-C40	mg/kg MS	210	<10	<10	370	16	770	90	720	<10	1000
Hydrocarbures> C10-C12	mg/kg MS	<10	<10	<10	<20	<20	<10	<10	<20	<10	ND
Hydrocarbures> C12-C16	mg/kg MS	<10	<10	<10	36	<20	<10	<10	<20	<10	ND
Hydrocarbures> C16-C21	mg/kg MS	19	<10	<10	53	<20	110	<10	140	<10	ND
Hydrocarbures> C21-C35	mg/kg MS	140	<10	<10	230	<20	520	59	440	<10	ND
Hydrocarbures> C35-C40	mg/kg MS	36	<10	<10	39	<20	120	12	88	<10	ND
Heavy Metal											
Mercure (Hg)	mg/kg MS	0.13	<0.05	<0.05	0.39	0.09	0.45	0.97	0.42	<0.05	7
Arsenic (As)	mg/kg MS	<5	<5	<5	<5	14	<5	<5	<5	<5	37
Plomb (Pb)	mg/kg MS	24	<5	<5	96	15	84	18	140	<5	400
Cadmium (Cd)	mg/kg MS	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	20
Chrome (Cr)	mg/kg MS	81	33	38	45	270	89	61	170	21	130
Cobalt (Co)	mg/kg MS	3.5	<2	<2	5.2	2,1	3	<2	4	<2	240
Cuivre (Cu)	mg/kg MS	23	4.5	4.1	57	4.8	35	8.2	49	<3	190
Nickel (Ni)	mg/kg MS	9.6	<3	<3	22	<3	7.3	3.7	11	<3	140
Soufre (S)	mg/kg MS	170	33	22	1500	440	630	180	3600	24	10
Zinc (Zn)	mg/kg MS	140	13	11	430	27	190	32	240	6.8	9000
Volatile halogenated hydrocarbons (COHV)											
1,1-Dichloroéthane	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
1,1-Dichloroéthylène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
Dichlorométhane	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND

Tétrachloroéthylène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
1,1,1-Trichloroéthane	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
Tétrachlorométhane	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
Trichlorométhane	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
Trichloroéthylène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
Chlorure de vinyle	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
cis-1,2-Dichloroéthylène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
trans-1,2-Dichloroéthylène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
Chemical element	Unit	Abobo 01	Maca 01	Maca 02	Akouedo 01	Akouedo 02	Dokui 01	Dokui 02	Dokui 03	TM	Gouv Norm (mg/kg)
Benzene and aromatic (CAV - BTEX)											
Benzène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1
Toluène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	5
Ethylbenzène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	25
m-, p-Xylène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	5
o-Xylène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	5
Cumène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
m-, p-Ethyltoluène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
Mésitylène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
o-Ethyltoluène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
Pseudocumène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
Polycyclic aromatic hydrocarbons (PAH)											
Naphthalène	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Acénaphtylène	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Acénaphtène	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Fluorène	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND

Phénanthrène	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Anthracène	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Fluoranthène (*)	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Pyrène	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Benzo(a)anthracène	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Benzo(b)fluoranthène (*)	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Benzo(k)fluoranthène (*)	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Benzo(a)pyrène (*)	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Dibenzo(ah)anthracène	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Indéno(123-cd) pyrène (*)	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Benzo(ghi)pérylène (*)	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Chemical element	Unit	Abobo 01	Maca 01	Maca 02	Akouedo 01	Akouedo 02	Dokui 01	Dokui 02	Dokui 03	TM	Gouv Norm (mg/kg)
Benzene and aromatic (CAV - BTEX)											
Benzène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1
Toluène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	5
Ethylbenzène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	25
m-, p-Xylène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	5
o-Xylène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	5
Cumène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
m-, p-Ethyltoluène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
Mésitylène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
o-Ethyltoluène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
Pseudocumène	mg/kg MS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND
Polycyclic aromatic hydrocarbons (PAH)											
Naphthalène	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND

Acénaphtylène	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Acénaphtène	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Fluorène	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Phénanthrène	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Anthracène	mg/kg MS	<0,03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Fluoranthène (*)	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Pyrène	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Benzo(a)anthracène	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Benzo(b)fluoranthène (*)	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Benzo(k)fluoranthène (*)	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Benzo(a)pyrène (*)	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Dibenzo(ah)anthracène	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Indéno(123-cd)pyrène (*)	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Benzo(ghi)pérylène (*)	mg/kg MS	<0.03	<0.03	<0.03	<0.03	<0.05	<0.03	<0.03	<0.05	<0.03	ND
Chemical element	Unit	Abobo 01	Maca 01	Maca 02	Akouedo 01	Akouedo 02	Dokui 01	Dokui 02	Dokui 03	TM	Gouv Norm (mg/kg)
Mercaptans and sulfurs molecules											
Méthylmercaptan	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND
Ethylmercaptan	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND
Propyl mercaptan	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND
n-Butylmercaptan	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND
n-Pentylmercaptan	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND
Diméthylsulfure	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND
Diméthyldisulfure (DMDS)	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND

Diéthyldisulfure	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND
Diéthylsulfure	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND
Di-n-propylsulfure	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND
Di-n-butylsulfure	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND
sec-Butylmercaptan	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND
iso-Butylmercaptan	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND
Disulfure de méthyléthyl	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND
Ethyl-i-propylmercaptan	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND
Ethyl-n-propylmercaptan	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND
tert-Butylmercaptan	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND
Diethyldisulfur	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND
2-Methyl-2-propanethiol	mg/kg MS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0,05	<0.05	ND

Abbreviation	**Signification**
Gouv Norm (mg/kg)	Ivory Cost Government Norm
ND	No Determinated
TM	Witness (Abidjan)

Table 3 show the analyses of soils and strong matters. The results of analyses of toxic waste contaminated soils show that the grand category of compounds present in the toxics waste are these: the global parameters of indications of hydrocarbons, the heavy metals, the volatile halogenated hydrocarbons (COHV), the benzene and the aromatic (CAV - BETEX), the polycyclic aromatic hydcarbures (HAP), the mercaptants rich in sulphides.

The resulted from analysis of these contaminated soils have been compared with a witness's site no affected by the toxic waste of Abidjan. These results suggest that the securities parameters measured in the contaminated soils are appreciably the same that these control site. This seems to show a good remediation of the contaminated soils.

These results have been compared thereafter to the governmental norms of depollution of affected sites. These norms correspond to the limits of dépollution judged acceptable by the government of Ivory Coast. So, it seems important to us to compare the results of analysis of contaminated soils with these norms. The report that we do after this work is that the results of analysis of our contaminated soils are in under of the limit of deppollution accepatble by the government of Ivory Coast. This seems to confirm a good remediation of the toxic waste contaminated soils.

However, the norms gouvernermentale take in account or better, only exist for an infine part of the chemical compounds present in the contaminated soils. So we think that, we are in right to ask us if the skipped chemical elements in the norm don't represent a risk for the senorio of possible use of the soils affected by this dangerous waste. It is about the global parameters of hydrocarbon indication that out set the Hydrocarbon C10-C40 don't take the other chemical compounds in account of this category. The Benzene and the aromatic are only processed about 50%. All volatile halogenated compounds (COHV), the polycyclic aromatic hydrocarbons (PAH), the mercaptant rich in sulphides is completely absente of the governmental norms. These different chemical elements are no determined by this norm.

The norm of remediation fixed by the government of Ivory Coast doesn't represent a sure abrit concerning sanitation risk in this sense that the concentrations of the chemical elements remaining on the sites after depollution can constitute a sanitation risk according to the furtur use of these different soils said "decontaminated."

Thus, we will conduct an assessment of the sanitation risks of these toxic waste soils. But let us see the results of the anlyses of the superficial, underground waters and air after remediation.

Table 4 analyses of superficial and underground water

Chemical element	Unit	CLG01	CLG02	CLG03	CLG04	CLG05	CLG06	KZI01	KZI02	KZI03	KZI05	KZI06	KZI07	KZI08	MCA01	Netherlander Norms (µg/l)
Global parameters / Indication																
Indicehydrocarbure C10-C40	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	600000
Hydrocarbures> C10-C12	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
Hydrocarbures> C12-C16	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
Hydrocarbures> C16-C21	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
Hydrocarbures> C21-C35	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
Hydrocarbures> C35-C40	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
Heavy Metal																
Arsenic (As)	µg/l	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	60
Plomb (Pb)	µg/l	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	75
Cadmium (Cd)	µg/l	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	6
Chrome (Cr)	µg/l	10	<10	<10	13	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	30
Cobalt (Co)	µg/l	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	100
Cuivre (Cu)	µg/l	6,1	<6	7	8,7	8,1	<6	<6	9,4	<6	<6	<6	<6	<6	8	75
Nickel (Ni)	µg/l	24	<10	<10	<10	<10	<10	12	<10	<10	<10	<10	<10	<10	<10	75
Soufre (S)	µg/l	20000	9200	23000	18000	22000	24000	24000	34000	43000	58000	41000	38000	18000	410	ND
Zinc (Zn)	µg/l	130	40	<20	96	64	<20	42	120	<20	80	97	53	370	43	800
Mercure (Hg)	µg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.3
Volatile halogenated hydrocarbons (COHV)																
Chlorure de vinyle	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ND
Dichlorométhane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ND
cis-1,2-Dichloroéthylène	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ND

trans-1,2-Dichloroéthylène	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ND
Trichlorométhane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ND
1,1,1-Trichloroéthane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ND
Tétrachlorométhane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ND
Trichloroéthylène	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ND
Tétrachloroéthylène	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ND
1,1-Dichloroéthane	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ND
1,1-Dichloroéthylène	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ND
Chemical element	Unit	CLG01	CLG02	CLG03	CLG04	CLG05	CLG06	KZI01	KZI02	KZI03	KZI05	KZI06	KZI07	KZI08	MCA01	Netherlander Norms (µg/l)
Benzene and aromatic (CAV - BTEX)																
Benzène	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	30
Toluène	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	150
Ethylbenzène	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1000
o-Xylène	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	70
m-, p-Xylène	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	70
Polycyclic aromatic hydrocarbons (PAH)																
Naphthalène	µg/l	<0.02	<0.02	<0.02	<0.03	<0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0,02	<0.02	<0.02	<0.02	ND
Acénaphtylène	µg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0,02	<0.02	<0.02	<0.02	ND
Acénaphtène	µg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0,02	<0.02	<0.02	<0.02	ND
Fluorène	µg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0,02	<0.02	<0.02	<0.02	ND
Phénanthrène	µg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0,02	<0.02	<0.02	<0.02	ND
Anthracène	µg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0,02	<0.02	<0.02	<0.02	ND
Fluoranthène (*)	µg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0,02	<0.02	<0.02	<0.02	ND
Pyrène	µg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0,02	<0.02	<0.02	<0.02	ND
Benzo(a)anthracène	µg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0,02	<0.02	<0.02	<0.02	ND

Chrysène	µg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0,02	<0.02	<0.02	<0.02	ND
Benzo(b)fluoranthène (*)	µg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0,02	<0.02	<0.02	<0.02	ND
Benzo(k)fluoranthène (*)	µg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0,02	<0.02	<0.02	<0.02	ND
Benzo(a)pyrène (*)	µg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0,02	<0.02	<0.02	<0.02	ND
Dibenzo(ah)anthracène	µg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0,02	<0.02	<0.02	<0.02	ND
Indéno(123-cd)pyrène (*)	µg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0,02	<0.02	<0.02	<0.02	ND
Benzo(ghi)pérylène (*)	µg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0,02	<0.02	<0.02	<0.02	ND
Chemical element	Unit	CLG01	CLG02	CLG03	CLG04	CLG05	CLG06	KZI01	KZI02	KZI03	KZI05	KZI06	KZI07	KZI08	MCA01	Netherlander Norms (µg/l)
Mercaptans and sulfurs molecules																
Méthylmercaptan	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
Ethylmercaptan	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
Propyl mercaptan	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
n-Butylmercaptan	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
n-Pentylmercaptan	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
Diméthylsulfure	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
Diméthyldisulfure (DMDS)	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
Diéthylsulfure	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
Di-n-propylsulfure	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
Di-n-butylsulfure	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
sec-Butylmercaptan	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
iso-Butylmercaptan	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
Disulfure de méthyléthyl	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
Ethyl-i-propylmercaptan	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
Ethyl-n-propylmercaptan	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND
2-Methyl-2-propanethiol	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND

Diethyldisulfure	μg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND

Abbreviation	Signification
CLG01	Vridi (Cap Logistique 01)
CLG02	Vridi (Cap Logistique 02)
CLG03	Vridi (Cap Logistique 03)
CLG04	Vridi (Cap Logistique 04)
CLG05	Vridi (Cap Logistique 05)
CLG06	Vridi (Cap Logistique 06)
KZI01	Koumassi 01
KZI02	Koumassi 02
KZI03	Koumassi 03
KZI05	Koumassi 05
KZI06	Koumassi 06
KZI07	Koumassi 07
KZI08	Koumassi 08
MCA01	Maca 1
Netherlander Norms (μg/l)	Netherlander underground water Norms (μg/l)

Table 4 show the analyses of superficial and underground water. The results of the analyses of the superficial and underground waters being close to toxic waste contaminated soils show that the grand category of compounds present in the toxics waste are these: the global parameters of indications of hydrocarbons, the heavy metals, the volatile halogenated hydrocarbons (COHV), the benzene and the aromatic (CAV - BETEX), the polycyclic aromatic hydcarbures (HAP), the mercaptants rich in sulphides.

These results have been compared to the international norms of Netherland intervention for the depollution of the underground waters. These norms correspond to the limits of depollution judged acceptable by Netherland and used in this situation by the government of Ivory Coast. The report that we do after this comparison is that the results of analysis of the superficial waters and the underground waters being close to toxic waste contaminated soils are in under of the limit of deppollution international norms of Netherland intervention for the depollution of the underground waters. This seems to show in a first approach that the superficial and underground waters have not been affected by this episode of contamination by the toxic waste.

However, the international norms of Netherland intervention for the depollution of the underground waters take in account or better, only exist for an infine left of part of the chemical compounds in the superficial and underground waters. So we think that, we are in the right to ask us if the skipped chemical elements in the norm don't represent a risk for the senorio of possible use of the superficial and underground waters being close to toxic waste contaminated soils. It is about the global parameters of hydrocarbon indication that out set the Hydrocarbon C10-C40 don't take the other chemical compounds in account of this category. All of volatile halogenated compounds (COHV), of polycyclic aromatic hydrocarbons (HAP), of mercaptants rich in sulphides are completely absentees of the international norms of Netherland intervention. These different chemical elements are no determined by this norm.

The international norms of Netherland intervention of fixed and accepted depollution by the government of Ivory Coast don't represent a sure abrit concerning sanitation risk in this sense that the concentrations of the chemical elements remaining on the sites after remediation can constitute a sanitation risk according to to the furtur use of these different sites said "decontaminated". besides the Netherland norms seem for us a lot more adapted for a moderated climate country or to mediteranée climate country rather than for a tropical climate country as the our. In effects the temperature dependences and the parameters as the pH can constituted limiting factors the reliability of the international Netherland intervention norms for tropical climate.

Thus, for the same reason as soils, we will conduct an assessment of the sanitation risks of the superficial and underground waters being close to toxic waste contaminated soils. Now we are going presente to you the analyses of air.

Table 5 analyses of air

Désignationd'échantillon	**Unit**	**DK1**	**DK2**	**MAC 1**	**MAC 2**	**CLA 1**	**CLA2**	**KZA1**	**KZI A2**	**AD A1**	**AD A2**	**AD V**	**BC A1**	**BC A2**	**DjV1**	**DjV2**	**SONG A**
Mercaptans and sulfurs molecules																	
Méthylmercaptan	µg G	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylmercaptan	µg G	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Propyl mercaptan	µg G	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
n-Butylmercaptan	µg G	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
n-Pentylmercaptan	µg G	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
sec-Butylmercaptan	µg G	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
iso-Butylmercaptan	µg G	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethyl-i-propylmercaptan	µg G	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
tert-Butylmercaptan	µg G	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Heavy Metal																	
Mercure (Hg)	µg G	0.054	0.054	0.064	0.055	0.057	0.061	0.056	0.054	0.055	0.055	0.059	0.06	0.057	0.056	0.062	0.054
Cadmium (Cd)	µg G	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Antimoine (Sb)	µg G	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Arsenic (As)	µg G	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Chrome (Cr)	µg G	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Cuivre (Cu)	µg G	0.7	1.3	0.75	1.2	0.75	0.7	0.75	0.6	0.65	0.65	0.8	0.65	0.95	0.75	1	0.6
Nickel (Ni)	µg G	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Zinc (Zn)	µg G	0.75	1.2	0.85	1.3	0.7	0.75	0.95	1.1	0.8	0.95	1.1	0.9	1	1	0.85	0.65
Fine dusts																	
Poussières PM 2,5	mg MS	0.04	<0.01	0.09	<0.01	<0.01	0.04	0.04	0.56	0.06	0.04	0.08	<0.01	<0.01	0.01	<0.01	<0.01
Gas of discharge																	
hydrogne Sulfur (H_2S)	ppm. Vol G	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Benzene and aromatic (CAV - BTEX)																	
Benzène	µg G	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluène	µg G	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzène	µg G	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
m-, p-Xylène	µg G	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
o-Xylène	µg G	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cumène	µg G	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Polycyclic aromatic hydrocarbons (PAH)																	
Naphthalène	µg G	0.2	0.21	0.2	0.15	0.18	0.15	0.15	0.24	0.19	0.2	0.12	0.15	0.22	0.2	0.26	0.18
Acénaphtylène	µg G	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acénaphtène	µg G	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorène	µg G	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phénanthrène	µg G	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracène	µg G	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthène (*)	µg G	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrène	µg G	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracène	µg G	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysène	µg G	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthène (*)	µg G	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthène (*)	µg G	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrène (*)	µg G	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo(ah)anthracène	µg G	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(ghi)pérylène (*)	µg G	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indéno(123-cd)pyrène (*)	µg G	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Abbreviation	**Signification**
DK1	Dokui 1
DK2	Dokui 2
MAC 1	Maca 1
MAC 2	Maca 2
CLA 1	Vridi (Cap Logistique 1)
CLA2	Vridi (Cap Logistique 2)
KZA1	Koumassi 1
KZI A2	Koumassi 2
AD A1	Akouedo 1
AD A2	Akouedo 2
AD V	Akouedo village
BC A1	Baie de Cocody 1
BC A2	Baie de Cocody 2
DjV1	Djibi village 1
DjV2	Djibi village 2
SONG A	Witness (rural zone of Abidjan)

Table 5 show the analyses of air. The results of the air analyses being on the toxic waste contaminated sites and soils show that the grand category of compounds present in the toxics waste are these : the mercaptants rich in sulphides, the heavy metals, the benzene and the aromatic (CAV - BETEX), the polycyclic aromatic hydcarbures (HAP).

The resulted from analysis of air being on these toxic waste contaminated sites and soils have been compared with a control site of a no affected by the toxic waste close situated to Abidjan. These results suggest that the securities parameters measured in air being on the toxic waste contaminated sites and soils are appreciably the same that this control site. This seems to show a good remediation of air being on these toxic waste contaminated sites and soils.

However, no norm allows us to determine the quality of air, So think that, we are in right to ask us if the comparison of analysis resulted of air being on the toxic waste contaminated sites and soils with a control site of a no affected by the toxic waste close situated to Abidjan is sufficient to say that the quality of air on these zones contaminated is completely restored after remediation. It seems that the quality of air not presented anymore of risk.

The analysis of air being on the toxic waste contaminated sites and soils would represent a sure abrit concerning sanitation risk in this sense that the concentrations of the chemical elements remaining on the sites after remediation are comparable to the air of an apparently virgin control site of all contamination. The quality of air doesn't present a risk according to the futur use of these different sites said "decontaminated."

In order to confirm or to invalidate this hypothesis the assessment of the sanitation risks of analysis of air being on the toxic waste contaminated sites and soils seems us indispensable.

3.1. Calculation of the risks

In order to value the risk bound to the non-carcinogenic toxicity of a substance, we calculate a quotient of danger QD (Scooted, 2011):

QD = CI (mg/m3) / CMT (mg/m3)

In accordance with the circular of 10th December 1999 (France), the risk is considered like unacceptable if QD> 1 or if the sum of QD (global QD)> 1.

For the effects to doorstep, the possibility of intervening of a toxic effect at the target expresses itself by an indication of QD risk, definite as

⇒for the inhalation

$$QD_{inh} = \frac{CI}{RfC}$$

As a matter of principle of precaution, we added the systemic toxic risks of all substances, even though the effect, the organ targets and the mechanism of action was different.

The detail of the calculations of the exhibition doses (DJE and Ci) and QD are presented below in these Table.

Table 6a Spreadsheet - inhalation by volatilization in the external air from the underground waters - Substance non carcinogenic (Children) Children - Substances to doorstep

No carcinogenic substances	Cm box Model (mg/m³)	ti (ratio h of exhibition/24h)	F (ratio j of exhibition/365j)	T (year)	TM (year)	Ci = Cm * ti * F * T / Tm (mg/m3)	VTR inhalation mg/m3
Naphtalène	1,19E-08	0,058333333	1	1	1	6,94167E-10	3,00E-03
Acénaphtène	1,48E-10	0,058333333	1	1	1	8,63333E-12	2,00E+00
Cis 1,2-dichloroéthylène	1,06E-04	0,058333333	1	1	1	6,18333E-06	3,00E-02
Trans 1,2-dichloroéthylène	6,65E-07	0,058333333	1	1	1	3,87917E-08	7,94E-01
Chlorure de vinyle	1,96E-04	0,058333333	1	1	1	1,14333E-05	1,00E-01

Table 6b spreadsheet - inhalation by volatilization in the external air from the underground waters - Substance non carcinogenic (Employees of the adult parklands)

Used of the adult parklands - Substances to doorstep

No carcinogenic substances	Cm box Model (mg/m³)	ti (ratio h of exhibition/24h)	F (ratio j of exhibition/365j)	T (year)	TM (year)	Ci = Cm * ti * F * T / Tm (mg/m3)	VTR inhalation mg/m3
Naphtalène	7,44E-09	0,333333333	0,547945205	1	1	1,3589E-09	3,00E-03
Acénaphtène	9,22E-11	0,333333333	0,547945205	1	1	1,68402E-11	2,00E+01
Cis 1,2-dichloroéthylène	6,60E-05	0,333333333	0,547945205	1	1	1,20548E-05	3,00E-02
Trans 1,2-dichloroéthylène	4,16E-07	0,333333333	0,547945205	1	1	7,59817E-08	7,94E-01
Chlorure de vinyle	1,23E-04	0,333333333	0,547945205	1	1	2,24658E-05	1,00E-01

Table 7a Spreadsheet - inhalation by volatilization of soils toward the external air - non carcinogenic Substance (Children) Children - Substances to doorstep

No carcinogenic substances	Cm box Model (mg/m³)	ti (ratio h of exhibition/24h)	F (ratio j of exhibition/365j)	T (year)	TM (year)	Ci = Cm * ti * F * T / Tm (mg/m3)	VTR inhalation mg/m3
Naphtalène	4,67E-15	0,058333333	1	1	1	2,72192E-16	3,00E-03
Acénaphtylène	2,92E-19	0,058333333	1	1	1	1,70443E-20	2,00E+01
Acénaphtène	0,00E+00	0,058333333	1	1	1	0,00E+00	2,00E+01
Fluorène	0,00E+00	0,058333333	1	1	1	0,00E+00	2,00E+01
Trichloroéthylène	5,14E-05	0,058333333	1	1	1	3,00082E-06	2,00E-03
Cis 1,2-dichloroéthylène	8,94E-10	0,058333333	1	1	1	5,21658E-11	3,00E-02
Trans 1,2-dichloroéthylène	8,75E-10	0,058333333	1	1	1	5,10295E-11	7,94E-01
Chlorure de vinyle	2,64E-08	0,058333333	1	1	1	1,53915E-09	1,00E-01
HCT C10-C16	2,83E-13	0,058333333	1	1	1	1,65278E-14	1,00E+00

Table 7b Spreadsheet - inhalation by volatilization of soils toward the external air - non carcinogenic Substance (Employees of the adult parklands); Used of the adult parklands - Substances to doorstep

No carcinogenic substances	Cm box Model (mg/m^3)	ti (ratio h of exhibition/24h)	F (ratio j of exhibition/365j)	T (year)	TM (year)	Ci = Cm * ti * F * T / Tm (mg/m3)	VTR inhalation mg/m3
Naphtalène	2,33E-15	0,333333333	0,547945205	1	1	4,26132E-16	3,40E-02
Acénaphtylène	1,46E-19	0,333333333	0,547945205	1	1	2,66838E-20	2,00E+01
Acénaphtène	0,00E+00	0,333333333	0,547945205	1	1	0	2,00E+01
Fluorène	0,00E+00	0,333333333	0,547945205	1	1	0	2,00E+01
Trichloroéthylène	2,57E-05	0,333333333	0,547945205	1	1	4,69796E-06	2,00E-03
Cis 1,2-dichloroéthylène	4,47E-10	0,333333333	0,547945205	1	1	8,16686E-11	3,00E-02
Trans 1,2-dichloroéthylène	4,37E-10	0,333333333	0,547945205	1	1	7,98896E-11	7,94E-01
Chlorure de vinyle	1,32E-08	0,333333333	0,547945205	1	1	2,40963E-09	1,00E-01
HCT C10-C16	1,42E-13	0,333333333	0,547945205	1	1	2,58752E-14	1,00E+00

All securities of danger quotient calculated are lower to 1 what shows that the risk is considered like acceptable (Table 6a, 6b, 7a, 7b). The quotient of danger being calculated for no carcinogenic, we can say that the risk bound to the site and soils affected by toxic waste within the district of Abidjan is acceptabe according to the French norms.

3.2. Carcinogenic effect

In order to value the risk bound to the carcinogenic effects of the substances, we calculate an excess of risk individual ERI

$$ERI = CI\ (\mu g/m3) \times ERUi\ (\mu g/m3)\text{-}1$$

For the effects without doorstep, an Individual Risk Excess (ERI) is defined like follows:

⇒ for the inhalation:

$Erin = CI \times Erin$

The supplementary possibility to develop the effect in relation to the exhibition of bottom being expressed initially under the shape of a probability, a global ERI, for every definite exhibition script, will be able to be calculated while making:

- for every substance, the sum of the risks bound to each of the exhibition ways that concerns the individual of the script considered,
- the sum of the risks bound to each of the carcinogenic substances of the site or descended of the site,
- the sum of the risks bound to the different lengths of exhibition (chronicle) that can concern an individual.

According to the circular of 8th February 2007 (France) "a risk over 10^{-05} are ordinarily considered [...] as unacceptable".

The detail of the calculations of the exhibition doses (Ci) as well as some ERI are presented in these Table:

Table 8a Spreadsheet - inhalation by volatilization in the external air from the underground waters - Substance carcinogenic (Children); Children - Substances to doorstep

Carcinogenic substances	Cm box Model (mg/m³)	ti (ratio h of exhibition/24h)	F (ratio j of exhibition/365j)	T (year)	TM (year)	Ci = Cm * ti * F * T / Tm (mg/m3)	VTR inhalation mg/m3
Naphtalène	1,19E-08	0,058333333	1	40	70	3,96667E-10	3,40E-02
Acénaphtène	1,48E-10	0,058333333	1	40	70	4,93333E-12	8,00E-04
Cis 1,2-dichloroéthylène	1,06E-04	0,058333333	1	40	70	3,53333E-06	Pas de VTR
Trans 1,2-dichloroéthylène	6,65E-07	0,058333333	1	40	70	2,21667E-08	Pas de VTR
Chlorure de vinyle	1,96E-04	0,058333333	1	40	70	6,53333E-06	8,80E-03

Table 8b Spreadsheet - inhalation by volatilization in the external air from the underground waters - Substance carcinogenic (Employees of the adult parklands); Used of the adult parklands - Substances to doorstep

Carcinogenic substances	Cm box Model (mg/m³)	ti (ratio h of exhibition/24h)	F (ratio j of exhibition/365j)	T (year)	TM (year)	Ci = Cm * ti * F * T / Tm (mg/m3)	VTR inhalation mg/m3
Naphtalène	7,44E-09	0,333333333	0,547945205	6	70	1,16477E-10	3,40E-02
Acénaphtène	9,22E-11	0,333333333	0,547945205	6	70	1,44344E-12	8,00E-04
Cis 1,2-dichloroéthylène	6,60E-05	0,333333333	0,547945205	6	70	1,03327E-06	Pas de VTR
Trans 1,2-dichloroéthylène	4,16E-07	0,333333333	0,547945205	6	70	6,51272E-09	Pas de VTR
Chlorure de vinyle	1,23E-04	0,333333333	0,547945205	6	70	1,92564E-06	8,80E-03

Table 9a Spreadsheet - inhalation by volatilization of soils toward the external air - Substance carcinogenic (Children); Children - Substances to doorstep

Carcinogenic substances	Cm box Model (mg/m³)	ti (ratio h of exhibition/24h)	F (ratio j of exhibition/365j)	T (year)	TM (year)	Ci = Cm * ti * F * T / Tm (mg/m3)	VTR inhalation mg/m3
Naphtalène	4,67E-15	0,058333333	1	40	70	1,55538E-16	3,40E-02
Acénaphtylène	2,92E-19	0,058333333	1	40	70	9,73958E-21	8,00E-03
Acénaphtène	0,00E+00	0,058333333	1	40	70	0,00E+00	8,00E-04
Fluorène	0,00E+00	0,058333333	1	40	70	0,00E+00	8,00E-04
Trichloroéthylène	5,14E-05	0,058333333	1	40	70	1,71476E-06	4,10E-03
Cis 1,2-dichloroéthylène	8,94E-10	0,058333333	1	40	70	2,9809E-11	Pas de VTR
Trans 1,2-dichloroéthylène	8,75E-10	0,058333333	1	40	70	2,91597E-11	Pas de VTR
Chlorure de vinyle	2,64E-08	0,058333333	1	40	70	8,79514E-10	8,80E-03
HCT C10-C16	2,83E-13	0,058333333	1	40	70	9,44444E-15	Pas de VTR

Table 9b Spreadsheet - inhalation by volatilization of soils toward external air - Substance carcinogenic (Employees of the adult parklands**);** Used of the adult parklands - Substances to doorstep

Carcinogenic substances	**Cm box Model (mg/m3)**	**ti (ratio h of exhibition/24 h)**	**F (ratio j of exhibition/365j)**	**T (year)**	**TM (year)**	**Ci = Cm * ti * F * T / Tm (mg/m3)**	**VTR inhalation mg/m3**
Naphtalène	2,33E-15	0,333333333	0,547945205	6	70	3,65256E-17	3,40E-02
Acénaphtylène	1,46E-19	0,333333333	0,547945205	6	70	2,28718E-21	8,00E-03
Acénaphtène	0,00E+00	0,333333333	0,547945205	6	70	0	8,00E-04
Fluorène	0,00E+00	0,333333333	0,547945205	6	70	0	8,00E-04
Trichloroéthylène	2,57E-05	0,333333333	0,547945205	6	70	4,02683E-07	4,10E-03
Cis 1,2-dichloroéthylène	4,47E-10	0,333333333	0,547945205	6	70	7,00016E-12	Pas de VTR
Trans 1,2-dichloroéthylène	4,37E-10	0,333333333	0,547945205	6	70	6,84768E-12	Pas de VTR
Chlorure de vinyle	1,32E-08	0,333333333	0,547945205	6	70	2,06539E-10	8,80E-03
HCT C10-C16	1,42E-13	0,333333333	0,547945205	6	70	2,21787E-15	Pas de VTR

The results of the calculations show that all securities of Individual Risk excess are lower to 10-5, what implies according to the French circular of 08th February 2007, the risks bound to the carcinogenic effect of sites and soils affected the toxic waste in the district of Abidjan are considered like acceptable (Table 8a, 8b, 9a, 9b). The Individual Risk excess being calculated for the carcinogenic substances effect, it becomes possible for us to affirm that on the whole, the risk bound to the site and soils affected by the toxic waste within the district of Abidjan is acceptabe according to the French norms.

4. Conclusion

The assessment of the risks must take into account the futur use of the former site and soils polluted. To more understand our study, we considere three senario for these futur use. If we considere for exemple the constructional project of a circulation way with parking lot and parklands. The calculation of quotients of dangers, for the employees of the zone and the children playing on the parklands, is lower to 1 (value recommended by the circular of 8th February 2007). The risk is considered therefore like acceptable in this case. We also calculate the excesses of individual risks, for the employees of the zone and the children playing on the parklands and is lower to 10-5 (in accordance with the circular of 8th February 2007) the risk is considered therefore like acceptable in this case also.

If we considere respectively the project of construction of residence and the project of market culture. The calculation of quotients of dangers, is over to 1 in this case, as well for the children that for adult them resident on the sites or cultivating the soils of the sites affected by the toxic waste. The risk is not considered like acceptable in this case. We also calculate the excesses of individual risks, and we note that the global risk of the global risk is over to 10-5 in the case respectively the project of construction of residence and the project of market culture, as well for the children that for adult them resident on the sites or cultivating the soils of the sites affected by the toxic waste. So, in margin of these three proposed scenarios in the setting our works of thesis, if the use or the planning of the site had to be brought to change, it would be right to put up-to-date the analyzes sanitation risks consequently.

Even if though the unloading of the waste date at least 13 years already. The processes of remediation by local clay (OSTROM, 1990; 1993) or natural attenuation of the contaminated soils can take several years, the hundreds of years (Biache and al, 2008; 2011; 2014a; 2014b). In more the chemical elements as the heavy metals don't even deteriorate with time, even though the organic compound of its soils remains for example degradable with the clays (Faure and al, 1999; 2000; 2003; 2006a; 2006b). The use of the zones contaminated for the culture seems in a first unthinkable approach, but this remains possible for the people by ignorance, either by the fact that it could minimize the impact of such a pollution after some years. The toxic waste that has been unloading in the district of Abidjan are classified like dangerous waste. It seems important to us to circumscribe the different sites affected by the toxic waste with the corresponding danger mention. These sites will be able to being to declassify and to use in the respect of the environment and the human health.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors have no conflict of interests about the content of this article.

Statement of ethical approval

All of authors approved the ethical content of this article and they accepted to participate.

Statement of informed consent

All of authors declare that they have been informed and consent for the work submitted for publication. All authors have read and approved the final version manuscript.

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