Journal of Agricultural Chemistry and Environment, 2016, 5, 35-44
Published Online February 2016 in SciRes. http://www.scirp.org/journal/jacen
http://dx.doi.org/10.4236/jacen.2016.51004

Evaluation of Pesticide Toxicity and Chemical Compounds Revealed in Soils of Sikasso and Segou (Mali)

Vital Traoré[1], Abdrahaman Sidibé[2], Ahoua Sika Edmond[3], Alou Coulibaly[4], Kalifa Keïta[5], Drissa Samake[5], Daniel Traoré[6], Sergey Kotelevtsev[7]

[1]Analytical Chemistry Laboratory, Department of Chemistry, Faculty of Science and Technology (FST), University of Sciences of Technics and Technology of Bamako (USTTB), Bamako, Mali
[2]Legislation Division and Phytosanitary Control, National Department of Agriculture, Bamako, Mali
[3]Laboratory for Environmental Sciences, Department of Science and Environment Management, University of Nangui Abrogoua, Abidjan, Ivory Coast
[4]Physics Laboratory and Soil Chemistry, Rural Polytechnic Institute (RPI/IFRA), Katibougou, Mali
[5]Laboratory of Analytical Chemistry, Faculty of Science and Technology (FAST), University of Sciences of Technics and Technology of Bamako (USTTB), Bamako, Mali
[6]Regional Directorate of Health Segou, Segou, Mali
[7]Laboratory Physicochemical of Biomembrane, University of State Moscow, Moscow, Russia
Email: vitaltraore@yahoo.fr

Received 31 December 2015; accepted 26 February 2016; published 29 February 2016

Copyright © 2016 by authors and Scientific Research Publishing Inc.
This work is licensed under the Creative Commons Attribution International License (CC BY).
http://creativecommons.org/licenses/by/4.0/
Open Access

Abstract

The contaminants of the ground are potentially harmful agents and when they are released in this medium, their persistence becomes an important concern. Because of the expressed interest, a certain number of pesticides and important chemicals and their toxicity are described in this article. The studies went on the determination of the concentration, the lethal amount of the organochlorinated compounds, chemical organophosphates, carbamates and compounds. One summer recorded 3 pesticides in 5 samples of the grounds of Sikasso and Segou (Mali). Their concentration varies from 20 (atrazine) with 45 g/kg of ground. The lethal amounts of the revealed poisons variable from 338 for phtalates to 28.710 mg/kg for hexane (alkane) thus evaluate their impact on the food chain. Organophosphates and the carbamates (insecticidal) involve a reduction of 34.2% of the number of *Cyprinus carpio* of fresh water. The atrazine contaminates drinking water, but the diuron modifies the behavior and the reproduction of fish by deteriorating their system of olfactive perception of natural substances. Important mortalities of birds are noted around the corn fields of Bougouni treated by the carbofuran. The pesticides involve at the man a reduction in fruitfulness, an increase in the risk of miscarriage of premature birth, congenital malformations and cancers.

How to cite this paper: Traoré, V., Sidibé, A., Edmond, A.S., Coulibaly, A., Keïta, K., Samake, D., Traoré, D. and Kotelevtsev, S. (2016) Evaluation of Pesticide Toxicity and Chemical Compounds Revealed in Soils of Sikasso and Segou (Mali). *Journal of Agricultural Chemistry and Environment*, **5**, 35-44. http://dx.doi.org/10.4236/jacen.2016.51004

Keywords

Evaluation, Toxicity, Pesticides, Chemical Compounds, Soils of Sikasso and Segou

1. Introduction

Agrosystem pollution by pesticides from Mali and its impact on the balance of nature are a current problem. Very little work on soil pollution of Sikasso and Segou and toxic transfer arrangements through the food chain. These pesticides pose a serious public health problem for users who are most at risk, but also for local people.

They cause biological effects in biological final consumer (human) cancer, birth defects, infertility, neurological problems or immune system and other.

Alongside these products are processed in different metabolites that may produce other repercussions on the human body. Most organic molecules are capable of forming "bound residues" in soils [1] [2].

The existence of bound residues poses the problem of their evolution, and in particular, that of their potential availability [3]. Some experiments have shown that bound residues can be usd by plants or soil microorganisms, or physico-chemical changes of soil constituents [4]-[6]. During our experiments, special emphasis has been placed on determining the concentration of pesticide residues, chemicals, lethal doses of pesticides formulation.

The determination of lethal doses allows changes in legislation. It makes a salutary pressure as monitoring air, water, soil and prohibitions on the manufacture or distribution of products considered hazardous.

The studies overall objective is assessing the toxicity of pesticides and chemicals through the food chain. The specific objectives are:

—Identify and quantify pesticide residues in soil samples Bougouni (Sikasso) and Niono (Segou);

—Determine the lethal doses of certain chemical compounds *in vivo*;

—Evaluate their toxicity in rodents.

2. Methodology

2.1. Collection and Processing of Soil Samples

Soil samples harvesting Bougouni and Niono were made in cotton fields, maize and rice three times of the year covering the dry and rainy seasons.

Composite soil samples were collected at the 0 - 40 cm horizon according to the method described by Mathieu and Pieltain [7]. It was delineated the 10 m × 10 m areas in the middle of the field. At each passage thirteen (13) basic samples according to the diagonals and the sides are drawn inside the square and a composite sample is formed. The samples were brought to the laboratory and stored at −20˚C until the actual analysis.

2.2. Determination of Pesticide Residues

Extraction of pesticide residues of 20 g of soil sample is carried out with 100 ml of hexane: isopropanol (75:25 V/V) in an Erlenmeyer flask of 125 ml. After decantation, 20 ml of the supernatant are stirred with 30 ml of distilled water in a separatory funnel. The organic phase is separated, dried over anhydrous sodium sulfate and then concentrated on rotary evaporator to 2 ml.

The extracts are preserved in the freezer has pillboxes −20˚C until analysis. The determination of pesticide was carried out by gas chromatography using an HP 5890A chromatograph equipped with an HP-5 column or SIL19CB CP column and with an ECD detector, all controlled by a computer and an integrated Chem Station chromatograms processing software. The identification and quantification of pesticide molecules are carried through internal calibration standards.

The detection limit was 0.02 µg/l. A HPLC 1100 Series Agilent Technology equipped with a column Eclipse XDBC8 and an iodine array detector (DAD) allowed the analysis of organophosphate.

2.3. Determination of Chemical Compounds

Sample analysis was performed according to EPA Method 8040, 8061, 8080, 8081 (US Environmental Protection Agency).

30 g of the soil sample are ground with a porcelain mortar and then sieved to 1 mm. It is placed in a cuvette ultrashort wave containing 20 ml of dichloromethane for 10 minutes to obtain the extract. The extract is concentrated until a volume of 1 ml, then the internal sampling standard was placed (naphthalene, phenanthrene, and chrysene) and then carried out the actual analysis.

2.4. Determination of Lethal Doses

Older white mice 30 days of starting treatment with the commercial products were used. Young animals were used because of their sensitivity to certain commercial products. We tested the commercial products containing more than 50% of active material, at a degree of purity greater than 98%. Insolubles in water are dissolved in neutral oil and olive inject subcutaneously in mice or rats using a needle 0.8 mm in diameter.

The weight of the commercial product gradually introduced into the mice is 5 or 10 or 15 g to observe the death of 50% of the population for 48 or 72 hours of incubation. The toxicity of chemicals is based on the value of their LD_{50}. The LD_{50} is the lethal dose to 50% of the tested animal population die. The harmful effects may be greater in humans than projected in the determination of the LD_{50} [8] [9].

3. Results and Discussion

Three (3) Pesticides (altrazine, carbofuran, endosulfan) were found in five (5) soil samples of Sikasso and Segou (**Table 1**). Their concentration varies from 0.006 mg/kg for endosulfan (ground floor 4 and 5) to 0.014 mg/kg to atrazine floor 1, floor 2 and floor 3). These values are less than or equal to the maximum residue limit set at 0.01 mg/kg for atrazine. The results of the experiment on the common freshwater carp have shown that organophosphates and carbamates (insecticides) cause a decrease of 34.2% in the number of *Cyprinus carpio*.

These results mirror those obtained by Gruber [10]. A high concentration of carbofuran or diazinon and chlorfenvinphos kills elderly carp a year after four hours of exposure, whereas low concentrations result in neurological disorders.

Previous work provided an update on the modification of the activity of digestive enzymes (lipase, alphachymotrypsine and carboxypeptidases) in carp by pyrethroids and methidation. A concentration of 20 µg/l of atrazine (pesticide used for maize) was recorded in drinking water Bougouni. This concentration is 10 times greater than that permitted for drinking water (2 µg/l) [11]. Diuron changes the behavior and reproduction of fish olfactory perception altering their system of natural substances [12]. Parathion is toxic in mice *in utero* and causes 15% mortality among them. The same killing effect occurs in birds subjected to elevated concentrations. Important bird mortalities are recognized around the corn fields treated with carbofuran. Organochlorine pesticides have varying effects on endocrine functions, fertility and the immune system of birds and mammals [13]. Some work have confirmed the decrease in reproduction, growth and increased risk of hyperthyroidism in mammals by pesticides [14] [15]. Many experiments corroborate the decline in fertility, increased risk of mis-carriage, premature deliveries, birth defects, cancer, damage to DNA and accumulation of pesticides in human's milk [16]-[19].

Figure 1 is chromatograms of chemical compounds found in soils Bougouni and Niono.

Chromatograms correspond to the detection time of the chemical compounds (acenaphthene and tetrahydronaphthalene) according to theirc oncentrationin soils Bougouni and Niono.

Soil sample analyzes have revealed a high concentration of phenol, nitrobenzene, methoxybenzene, hexa-decane-heptadecane and phthalates within five (5) samples of soil (**Table 2**). Parallel a high content of tri

Table 1. Concentration of pesticides found in soil Bougouni (Sikasso) and Niono (Segou).

Pesticides	Soil 1 mg/kg	Soil 2 mg/kg	Soil 3 mg/kg	Soil 4 mg/kg	Soil 5 mg/kg
Atrazine	0.014	0.014	0.014	0.010	0.010
Carbofuran	0.009	0.008	0.009	0.007	0.007
Endosulfan	0.009	0.008	0.009	0.006	0.006

Table 2. Results of chemical analyzes of soil Bougouni (Sikasso) and Niono (Segou).

№	Chemical compounds	Soil 1 µg/kg	Soil 2 µg/kg	Soil 3 µg/kg	Soil 4 µg/kg	Soil 5 µg/kg
	Phenols					
30	Phenol	9.2	11	10	6.3	6.6
203	Vanillin	0.0	17	8.9	0.0	131
61	4-Methylphenol	3.2	43	0.0	0.0	0.0
235	3,5-Bis(1,1-dimethyl)phenol	22	0.0	0.0	0.0	0.0
239	4,6-Bis(1,1-dimethyl)-2 methylphenol	4.4	0.0	0.0	0.0	0.0
309	2,4-Dibutyl-nitrophenol	0.0	5.6	11	2.8	14
	Benzenes					
68	Nitrobenzene	44	43	63	20	38
19	Methoxybenzene	248	230	324	480	438
74	1-Chloro-4-methoxybenzene	7.6	7.0	10	16	0.27
78	1-Chloro-2-methoxybenzene	14	14	20	23	0.0
147	2,4-Dichloro-1-methoxybenzene	2.1	2.3	0.0	3.3	2.4
148	2-Bromopropenylbenzene	5.2	0.0	0.0	0.0	0.0
158	1-Bromo-2-(2-propenyl)benzene	1.2	1.6	1.4	0.0	0.0
223	2,2-Dibromopropenylbenzene	3.2	273	45	2.1	0.0
	Polycyclic Aromatic Hydrocarbons(PAH)					
109	Naphtalene	13	10	12	26	21
153	2-Methylnaphtalene	6.8	7.0	7.6	13	11
162	1-Methylnaphtalene	15	15	17	24	21
194	Naphtalene, C2	5.2	5.6	6.3	9.3	22
196	Naphtalene, C2	7.6	8.6	9.5	4.1	33
204	Naphtalene, C2	7.9	20	5.9	38	22
213	Naphtalene, C2	5.5	5.7	4.3	42	22
221	Naphtalene, C2	3.6	4.0	4.4	37	11
241	Naphtalene, C3	0.3	5.0	5.2	7.4	10
243	Naphtalene, C3	0.1	2.4	2.2	2.4	16
253	Naphtalene, C3	7.5	2.0	9.1	18	18
259	Naphtalene, C3	5.7	8.0	13	23	25
267	Naphtalene, C3	4.5	9.1	12	29	22
304	2,6-Diisopropylnaphtalene	15	21	11	7.7	27
308	2,6-Diisopropylnaphtalene	22	119	59	15	34
324	2,6-Diisopropylnaphtalene	37	108	84	17	90
325	2,7-Diisopropylnaphtalene	40	0.0	0.0	18	52
331	2,8-Diisopropylnaphtalene	32	108	0.0	7.2	36
188	Acenaphtene	11	10	12	62	31
272	Fluorene	4.0	5.8	0.0	17	11
352	Phenanthrene	37	40	37	94	64

Continued

354	Anthracene	4.4	4.1	3.6	13	5.2
385	Methylphenanthrene	6.0	5.2	4.8	13	8.7
389	Methylphenanthrene	7.0	5.9	6.1	17	10
395	Methylphenanthrene	4.7	4.1	3.6	12	7.8
396	Methylphenanthrene	5.9	4.4	3.7	13	7.5
421	Phenanthrene, C2	3.1	0.0	0.0	0.0	0.0
423	Phenanthrene, C2	1.6	0.0	0.0	0.0	0.0
424	Phenanthrene, C2	0.7	0.0	0.0	0.0	0.0
425	Phenanthrene, C2	0.4	0.0	0.0	0.0	0.0
427	Fluoranthene	7.4	7.1	6.2	18	13
436	Pyrene	4.9	7.3	4.8	15	9.6
		Biphenyls				
236	Biphenyl	0.2	0.0	2.6	3.2	0.0
195	p-Hydroxybiphenyl	4.6	0.0	0.0	2.3	0.0
244	o-Hydroxybiphenyl	0.4	8.1	0.78	0.0	0.0
299	1,1’-Biphenyl, C4	2.2	0.0	0.0	1.2	0.0
309	1,1’-Biphenyl, C4	0.0	0.0	0.0	1.6	0.0
		Alkylbenzenes				
1	Benzene, C2	6.0	3.0	1.8	9.1	9.6
11	Benzene, C2	1.4	1.9	3.0	6.2	5.2
33	Benzene, C3	1.2	5.7	2.5	2.5	4.1
39	Benzene, C4	11	11	1.2	16	9.9
46	Benzene, C4	12	1.6	2.9	9.2	0.85
53	Benzene, C4	0.9	7.5	32	4.3	6.1
76	Benzene, C4	0.0	2.4	3.23	8.5	3.5
79	Benzene, C4	160	0.4	31	1.5	0.13
89	Benzene, C5	2.9	11	30	2.1	21
95	Benzene, C5	15	1.5	0.50	0.58	0.38
115	Benzene, C6	2.5	0.32	2.6	35	7.1
120	Benzene, C6	27	2.8	34	34	28
123	Benzene, C6	1.6	17	4.0	4.4	28
124	Benzene, C6	2.2	2.3	1.7	1.0	3.2
129	Benzene, C6	5.3	4.6	5.0	3.2	3.9
138	Hexylbenzene	1000	1400	1020	633	695
142	Alkylbenzene	0.4	5.2	0.10	3.0	8.4
151	Alkylbenzene	0.6	45	0.49	5.1	12
247	Alkylbenzene	12	19	11	8.0	0.03
279	Alkylbenzene	2.4	28	8.9	6.3	0.0
284	Alkylbenzene	2.9	35	26	1.5	0.0
320	Alkylbenzene	1.5	6.6	27	7.8	0.0

Continued

348	Alkylbenzene	0.7	6.4	0.01	7.7	0.0
353	Alkylbenzene	1.0	8.0	60	1.5	0.0
355	Alkylbenzene	3.1	54	1.1	11	0.0
361	Alkylbenzene	1.7	4.6	3.5	1.1	0.0
367	Alkylbenzene	215	10	0.0	3.0	0.0
378	Alkylbenzene	2.9	6.6	0.0	2.2	0.0
		Alkanes				
12	2,4-Dimethylhexane	6.1	0.0	4.6	0.63	4.2
69	Undecane	15	12	19	80	47
77	Alkane	2.2	2.5	0.0	3.0	6.1
105	Dodecane	76	0.0	72	57	197
113	Alkane	5.5	5.6	0.0	11	8.4
141	Alkane	2.7	7.4	0.0	3.3	7.6
146	Tridecane	30	36	37	47	38
154	Alkane	14	8.3	12	18	12
157	Alkane	5.6	11.8	9.2	2.5	0.73
168	Alkane	2.2	170	23	1.8	10
171	Alkane	33	26	49	16	44
180	Alkane	23	35	20	6.5	13
186	Tetradécane	96	263	242	73	18
209	Alkane	25	45	40	4.1	93
210	Alkane	1.0	46	4.0	16	62
214	Alkane	3.3	11	53	13	105
226	Pentadecane	48	159	165	33	364
230	Alkane	13	40	40	11	71
251	Alkane	87	41	31	5.1	21
254	Alkane	12	90	11	4.1	15
257	Alkane	23	36	92	10	33
264	Alkane	14	22	23	16	300
268	Hexadecane	70	250	204	40	440
278	Alkane	1.4	11	87	3.4	90
281	Alkane	35	105	212	4.1	111
293	Alkane	10	60	88	26	48
303	Alkane	49	309	18	48	316
306	Alkane	135	24	142	3.6	217
322	Alkane	19	37	69	15	18
335	Alkane	26	110	4.9	11	322
341	Heptadecane	77	147	170	26	400
344	Alkane	66	135	100	22	161
362	Alkane	6.6	30	3.10	3.5	92

Continued

370	Alkane	36	5.5	16	3.8	33
398	Octadecane	35	47	5	7.5	216
403	Alkane	1.2	41	8.47	3.6	79
412	Alkane	4.9	24	38	1.8	61
422	Alkane	24	36	22	1.7	33
437	Alkane	13	4.2	43	2.9	40
442	Alkane	12	50	30	4.5	229
456	Alkane	20	53	53	0.33	111
487	Alkane	11	86	39	44	50
462	Alkane	19	71	38	11	24
468	Alkane	12	54	55	9.2	95
474	Alkane	17	91	131	8.1	134
484	Alkane	27	159	47	1.2	12
486	Alkane	6.5	77	33	13	70
489	Alkane	33	39	17	11	145
494	Alkane	18	47	20	14	100
		Thiophenes				
197	3,6-Dimethylbenzo[b]thiophene	0.9	6.15	24	0.0	10
343	Dibenzothiophene	1.5	0.0	0.0	0.0	2.4
		Phthalates				
212	Dimethylphthalate	20	22	19	54	30
269	Diethylphthalate	1197	710	489	102	846
366	Diisobutylphthalate	549	1100	1216	148	150
380	Phtalate	32	2.5	0.0	0.0	47
394	Dibutylphthalate	871	0.69	1.8	125	1420
441	Phthalate	2.7	2.7	0.0	0.0	56
465	Bis (2-ethylhexyl)phthalate	214	273	338	50	725
		Phosphates				
337	Tri(2-chloroethyl)phosphate	84	15	19	3.2	4.7
459	Triphenylphosphate	5.6	0.0	0.0	0.0	0.0
464	Cresyl diphenylphosphate	1.7	0.0	0.0	0.0	0.0
		Other chemical compounds				
256	Ethylparaben	6.5	30	0.0	2.1	234
10	Styrene	2.0	3.1	1.0	3.8	0.0
13	Cyclohexanone	5.4	7.6	13	4.5	0.0
75	Phenylethyl alcohol	0.8	1.4	0.0	0.0	0.0
287	Benzophenone	21	60	50	9.2	31
27	Benzaldehyde	37	46	48	47	40
48	Benzyl alcohol	20	10	18	13	4.0
62	Acetophenone	21	31	30	21	17

Continued

64	Methylbenzaldehyde	0.6	1.6	0.0	0.0	0.0
67	Dimethylbenzenemethanol	12	0.0	0.0	0.0	0.0
111	Methylsalicylate	12	50	0.0	0.0	0.0
124	2-Phenoxyéthanol	0.0	55	0.0	0.0	0.0
126	Benzothiazole	19	23	17	12	4.2
137	Caprolactam	0.0	186	0.0	0.0	19
156	N,N-dibutylformamide	0.0	5.5	0.0	0.0	0.0
249	Dibenzofuran	2.8	0.0	0.0	0.0	0.0
240	Diphenylether	0.0	0.0	0.0	4.8	73
252	Diphenylmethane	0.0	0.0	0.0	1.3	0.0

Soil 1: fields of Salif Sangaré (Bougouni); Soil 2: fields of Yacouba Doumbia (Bougouni); Soil 3: fields of Sidiki Sangaré (Bougouni); Soil 4: Laminabougou, fields of Madou Diarra (Niono); Soil 5: Minimana, fields of Modibo Diarra (Niono).

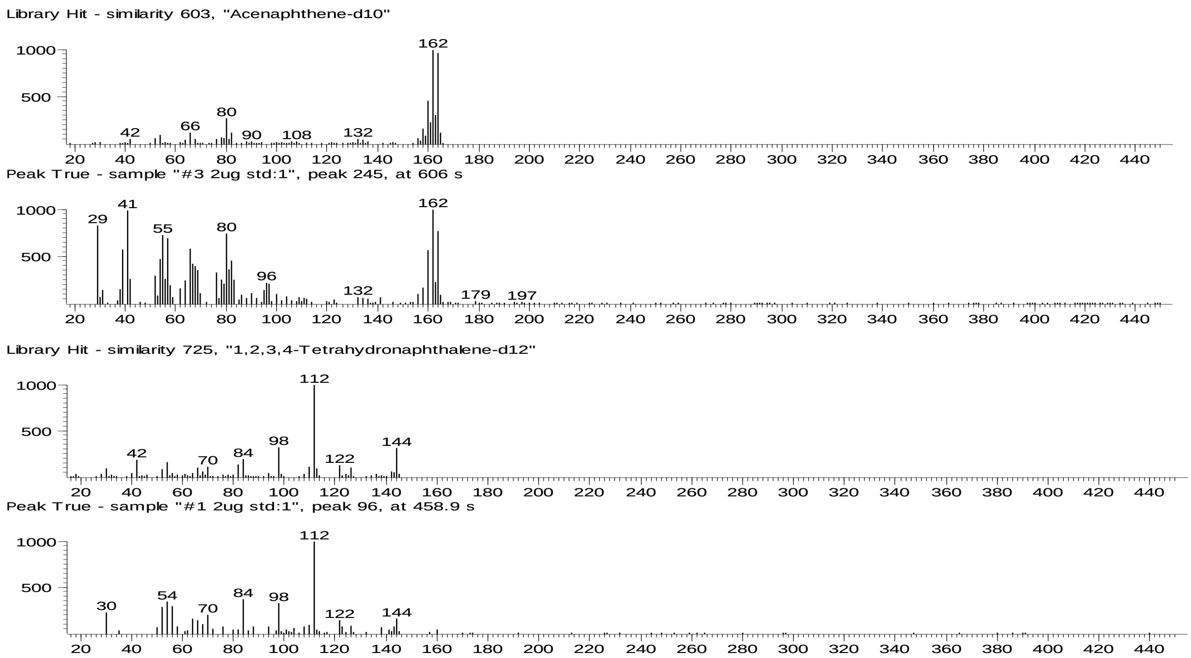

Figure 1. Chromatograms of chemical compounds found in soils Bougouni and Niono.

phosphate in the soil 1, propylparaben into the soil 2, 3 and 5 and benzaldehyde in soil 3 and 5. Their concentrations from 248 mg/kg for methexybenzene (soil 1), 1400 mg/kg for hexylbenzene (soil 2) 1216 mg/kg for diisobutylphthalate (floor 3) and 555 mg/kg for tetradecane (ground 5). Among the pesticides and chemicals identified in the different soil types we can cite the case of atrazine, carbofuran, endosulfan, the alkylbenzene, hexane (Alkane), phthalates, benzaldehyde and phenol. Atrazine, carbofuran and endosulfan. They are dangerous or toxic to the environment, very toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment. The alkylbenzene causes poisoning of the liver, increased tumors following dermal exposure of long-term damage to the skin, while phthalates (plastic) are toxic, dangerous to the environment and cause reduced fertility, a reduction in fetal weight, an effect on the liver and kidneys.

Among them, appears the di-ethylhexyl phthalate which is a high priority chemical compounds according to the WHO Phenol is environmentally harmful, irritating to the respiratory tract, causing the risk of eye damage, risk of impaired fertility. It is toxic to fish from 0.1 mg/l. Many toxic substances in the Bougouni and Niono soil can contaminate waterways through runoff, hence the need to make agricultural soil bioremediation.

Unlike non injected registered mortality rates exceed 98% witnessed in animals receiving lethal doses of commercial products considered (**Table 3**). The lethal effect more pronounced in mice depends on the toxicity

Table 3. Determination of lethal doses of chemical consists revealed in soil samples Bougouni (Sikasso) and Niono (Segou).

№	Chemicals	LD_{50} mg/kg	DJA mg/kg	Position in surrounding
1	Alkylbenzene	2000 In mice	negative	Intoxication liver, tumors Increased Following dermal exposure Long Term, DAMAGE caused to the skin.
2	Hexane (Alkane)	28,710 In mice	5	Respiratory tract irritation, risk of skin absorption, nausea, prolonged exposure causes effects on the central nervous system.
3	Phtalates	338 In mice	From 50 to 600	Toxic, dangerous to the environment, reduced fertility, reduced fetal weight, effect on the liver, kidneys.
4	Benzaldehyde	1430 In mice	0.40	Harmful to the environment, harmful by inhalation and ingestion. Irritating to eyes and respiratory system.
5	Phenol	400 in mice	0.12	Environmentally harmful, irritating to the respiratory tract, eye damage risk, risk of impaired fertility.

and the dose of injected pesticide. The lethal dose ranges from 7.36 mg/kg for endosulfan to 28,710 mg/kg in hexane (Alkane). Low values of lethal doses of the three (3) pesticide demonstrate their environmental toxicity. Expressions lethal doses of five (5) considered chemical compounds are large, so they are less toxic to the environment (except for phthalates). The various malformations are observed in some animal tests low concentration of toxic. An acceptable daily intake (ADI) is the amount of a substance per kilogram of body weight, which could absorb a person, daily, throughout his life, without causing him health problems. It is expressed in milligrams per kilogram of body weight of the individual per day (mg/kg/day). The excipient and joints impurities have no significant effect on results.

5. Conclusions

1) Three (3) pesticides are found in soil samples Bougouni (Sikasso) and Niono (Segou). This is atrazine, carbofuran and endosulfan.
2) Most biocidal identified persist in soil, disperse to other environmental systems (air, water) and result inmammals and man. A decrease in fertility, of reproductive effects, DNA damage, and cancer alters cell metabolism, neural activity, liver function and others.
3) The various malformations are observed in biota low concentration of xenobiotics found in samples of soils considered.
4) The lethal effect manifesting low concentration of active ingredients in their formulation reflects significant toxicity in test animals (mammals). The same effect is found in rats, mice and rodents nesting in Bougouni corn fields treated with carbofuran.

References

[1] Khan, S.U. (1982) Bound Pesticide Residues in Soil and Plants. *Residue Reviews*, **84**, 1-25. http://dx.doi.org/10.1007/978-1-4612-5756-1_1

[2] Calderbank, A. (1989) The Occurrence and Significance of Bound Pesticides Residues in Soil. *Reviews of Environmental Contamination and Toxicology*, **108**, 71-103. http://dx.doi.org/10.1007/978-1-4613-8850-0_2

[3] Barriuso, E., Benoit, P. and Bergheaud, V. (1994) Role of Soil Fractions in Retention and Stablisation of Pesticides in Soil. In: Copin, A., Houis, G., Pussemier, L. and Salembier, J.F., Eds., *Environmental Behaviour of Pesticides and Regulatory Aspects*, COST, European study Service, Rixensartn, Belgique, 138-143.

[4] Schiavon, M. and Soulas, G. (1983) Étude de la contamination des eaux de drainage et de la matière organique du sol par l'atrazine et ses dérivés de dégradation. Ministère de l'Environnement Convention No. 81398.

[5] Bertin, G. (1989) L'immobilisation de l'atrazine par la matière organique des sols. Une approche modélisée en conditions naturelles et au laboratoire. Thèse INPL, Nancy, France, 103 p.

[6] Demon, M. (1994) Influence des facteurs climatiques et des constituants du sol sur la dynamique de l'atrazine. Thèse INPL, Nancy, France, 111 p.

[7] Mathieu, C. and Pieltain, F. (1998) Analyse physique des sols. Méthodes choisies, TEC et DOC Lavoisier, Paris, 1-17.

[8] Forbes, V.E. and Forbes, T.L. (1997) Écotoxicologie: Théorie et applications. INRA éditions, 256 p.

[9] Ramade, F. (1992) Précis d'écotoxicologie. Masson, 300 p.

[10] Gruber, S.J. (1998) Organophosphate and Carbamate Insecticides in Agricultural Waters and Cholinesterase (ChE) Inhibition in Common Carp (*Cyprinus carpio*). *Archives of Environmental Contamination and Toxicology*, **35**, 391-396. http://dx.doi.org/10.1007/s002449900393

[11] Simon, L.M. (1999) Effects of Synthetic Pyrethroids and Methidation on Activities of Some Digestive Enzymes in Carp (*Cyprinus carpio* L.). *Journal of Environmental Science and Health*, **34**, 819-828.

[12] Saglio, P. and Trijasse, S. (1998) Behavioral Responses to Atrazine and Diuron in Goldfish. *Archives of Environmental Contamination and Toxicology*, **35**, 484-491. http://dx.doi.org/10.1007/s002449900406

[13] Guilette Jr., L.J. (2000) Organochlorine Pesticides as Endocrine Disruptors in Wildlife. *Central European Journal of Public Health*, **8**, 34-35.

[14] Osowski, S.L. (1995) The Decline of Mink in Georgia, North Carolina, and South Carolina: The Role of Contaminants. *Archives of Environmental Contamination and Toxicology*, **29**, 418-423. http://dx.doi.org/10.1007/BF00212510

[15] Martin, K.M., Rossing, M.A., Ryland, L.M., Digiacomo, R.F. and Freitag, W.A. (2000) Evaluation of Dietary and Environmental Risk Factors for Hyperthuroidism in Cats. *Journal of the American Veterinary Medical Association*, **217**, 853-856. http://dx.doi.org/10.2460/javma.2000.217.853

[16] Charlier, C.J. and Pontieux, G.J. (1999) Influence des résidus de pesticides sur la santé de l'homme. *Acta Clinica Belgica*, **l1**, 44-49.

[17] Veeramachaneni, D.N. (2000) Deteriorating Trends in Male Reproduction: Idiopathic or Environmental? *Animal Reproduction Science*, **60-61**, 121-130.

[18] Rojas, A., Ojeda, M.E. and Barraza, X. (2000) Congenital Malformations and Pesticides Exposures. *Revista Médica de Chile*, **128**, 399-404.

[19] Dogheim, S.M. (1996) Monitoring of Pesticides Residues in Human Milk. *Journal of AOAC International*, **79**, 111-116.