



Research Article

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**Pesticides for agricultural use in the province of Ben Slimane, Morocco:  
Inventory, toxicity and physicochemical quality of groundwater**

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**ABSTRACT**

*The study of the inventory of pesticides qualitatively and quantitatively and the quality monitoring of subterranean waters of BEN SLIMANE's province by the analysis of some physico-chemical parameters make us to release some interactions between agricultural pesticides and environment. Inquiries realized in the zone of study, allowed the inventory of 63 pesticides agricultural use marketed, among which 21 Insecticides, 9 Weed-killers and 33 Fungicides with a total of 57 active Materials. The use of pesticides with agricultural use in the zone of study and the comparison of their degree of toxicity with the international standards, allowed us to raise certain risks bound to these substances, particularly the phytosanitary products the active materials of which belong to the classes Ib and II which represent a potential risk on the various components of the ecosystem and which require a follow-up in the future in the various components to know METHOMYL, DELTAMETHRINE, CYPERMETHRIN, THIAMETHOXYL, IMIDACLOPRID, TAU-FLUVALINATE, DIMETHOATE, BIFENTHRIN, 2,4-D. The physico-chemical quality subterranean waters of the zone of study respects the Moroccan standard, except the conductivity in 4 municipality OULAD LOUTA, MELLILA, FDALATE and SIDI BETACHE who and exceeded the standard because of the effect of the geologic nature on the quality of waters.*

**Keywords:** Inventory, Pesticide, Impact, water, groundwater, toxicity, Ben Slimane

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**INTRODUCTION**

In Morocco, approximately 300-350 active substances are allowed and enter into the composition of more than 1000 trade specialties, including more than 80% approved for agricultural use [1].

Despite pesticides are approved they are not quite safe, if an adjuvant is considered to be inactive; it can become toxic depending on the manner of use. The aim of this work is to conduct investigations in BEN SLIMANE province whose purpose is to prospect points of sale of pesticides in the province in order to characterize; inventory and study places of final destination of the products sold. Define pesticides used for principal crops in the study area and establish toxicity of active contents sheets products used to define the impacts of pesticides on the different components of the ecosystem (environment, health...).

Parallel to this inventory a physicochemical study was conducted at the level of any point located in the area of inquiry, which aims to have an idea about the quality of the groundwater water.

**EXPERIMENTAL SECTION**

**General presentation of the study area:**

The BEN SLIMANE Province is located between the administrative capital RABAT and CASABLANCA metropolis with an area of 276 000 ha = 2 760 km<sup>2</sup> and a population of 233 123 inhabitants (2014) [2].

**Land in the study area:****Agriculture**

Agriculture is the most dominant activity in the Province's economy. The useful agricultural Surface (S.A.U) accounts for 55.8% of the land area of the Province is approximately 133.920 ha (3.767 irrigated Ha, 130.153 bour) spread over 14.033 farms. The rest are occupied by the forests with 23.7% (56.988 ha). The course and uncultivated land represent 20% (49.119 ha) [2].

**Major crops**

Grain farming represents the main activity of rain fed agriculture in the province with 61% of the useful agricultural Surface. Legumes, fodder and industrial crops represent respectively 9%, 8% and 1.4%. The distributions of these crops as well as average yields of the five latest companions are reported in the table below [2]:

**Table 1: The main crops in the study area (Source: Directorate Provincial agricultural of BEN SLIMANE)**

Species	Area (ha)		Yield (Qx/ha)		Production (Qx)	
	Bour	Irrigated	Bour	Irrigated	Bour	Irrigated
CEREALS	81850	-	16.5	-	1.342.550	-
Durum wheat	21.500	-	17	-	366.100	-
Common wheat	46.550	-	16.7	-	781.150	-
Barley	9.350	-	15	-	140.550	-
Corn	750	-	18	-	13.750	-
Oats grain	3.700	-	11	-	41.000	-
FODDER	11.080	445	43	2.625	476.440	116.812
Oats	8.250	-	29.6	-	244.200	-
Barley oven.	2.830	-	77	-	217.910	-
Alfalfa	-	20	-	250	-	500
Corn furnace.	-	400	-	400	-	160.000
Ryegrass	-	10	-	200	-	2.000
Other	-	15	-	200	-	3.000
LEGUMES	12.150	-	9.6	-	117.550	-
Bean	2.850	-	11	-	32.050	-
Pea	2.550	-	11	-	28.650	-
Lens	3.650	-	8	-	29.950	-
Chickpea	2.650	-	9	-	23.850	-
Dry beans	-	-	7	-	3.150	-
INDUSTRIAL CROPS	830	-	9	-	7.800	-
Sunflower	300	-	10	-	3.000	-
Sorghum	230	-	7	-	1.650	-
Lupin	300	-	10,5	-	3.150	-

**Hydrology of the area:****Surface water resources**

The BEN SLIMANE Province contains a large number of points of superficial water, sources and the (temporary and permanent) rivers which are used for irrigation and drinking water of the centres and douars[2].

**Course of surface waters:**

**Table 2: The course of surface waters in the study area (Source: Directorate Provincial agricultural of BEN SLIMANE)**

Oued Maleh	59.00 km in length
Oued N'fifikh	54.00 km in length
Oued Arrimen	22.50 km in length
Oued cherrat	21.50 km in length
Oued Ghbar	15, 00 km in length
Oued Bouznika	15.00 km in length
Oued Hassar	14.00 km in length
Oued Sikouk	6.00 km in length

**Groundwater resources**

It are very limited at the level of BEN SLIMANE Province the lithological nature of land existing, very low permeable and very poorly fed because of relatively abundant siltcovers which impede the infiltration of meteoric water and conversely promote surface runoff.

**The investigations on the ground:**

Several surveys were conducted in the area of study to agricultural use pesticide. These investigations have requested significant movements on the ground and contacts very close with farmers and traders (dealers) of the plant protection products.

The specifications developed for this purpose is structured along the following lines:

- Trade name
- Active ingredient
- Supplier and its place
- Culture destination
- Rate of application

During these investigations in the area, we prospected places of sale of pesticides in the region characterize an inventory of study places of final destination of the products sold and do a partial monitoring of the quality of groundwater.

Total 5 resellers of plant protection products have been identified in the survey area(table 3).

**Table 3: Information about resellers of plant protection products**

Seller	Name and first name	Place	Activity	Phone	Workforce
Seller 1	IDAMIA Brahim	Skhirat	Distribution of agricultural supplies	05 37 74 21 72	10 employees
Seller 2	IDAMIA Said	Skhirat	Distribution of agricultural supplies	06 61 56 78 66	3 employees
Seller 3	HAKIM Abdelah	Skhirat	Distribution of agricultural supplies	06 18 15 17 00	5 employees
Seller 4	MOHA Karim	Bouznika	Distribution of agricultural supplies	06 61 77 48 99	3 employees
Seller 5	BAIT Redouan	Bouznika	Distribution of agricultural supplies	05 37 87 90 00	2 employees

### The quality of groundwater:

#### Sampling points

Sampling Points were selected in 15 municipalities in the Province of BEN SLIMANE. These samples were divided according to the types of crops in the study area.

The study was conducted on 15 water samples from 15 wells in rural areas in the 15 municipalities of BEN SLIMANE during the period of April 2015. A water sampling was conducted in each well.

## RESULTS AND DISCUSSION

### Studies of physicochemical parameters of the underground waters of the study area:

All of the results of physicochemical analyses of 15 municipalities in the Province of BEN SLIMANE are represented in table 5. Their analysis will be based on the Moroccan standard [3]

**Table 4: Features 15 Commons in-situ physicochemical**

Place of sampling	Temperature (° C)	pH	Conductivity (µS/Cm)	Salinity (g/L)
CHERRAT	19,2	7,06	2400	1,1
MOUALIN ELGHABA	21,6	7,2	1683	0,7
AIN TIZGHA	15,2	7,52	1499	0,5
EL MANSOURIA	21	7,33	1905	0,8
ZIAIDA	21,3	7,71	889	0,2
MELLILA	19,3	7,2	4400	2,3
OULAD TOULAA	22,5	7,4	1170	0,3
OULAD LOUTA	20,1	7,33	3440	0,7
BIR ENNASR	21,2	7,6	826	0,2
BOUZNKA	19	7	2300	1,2
OULED MALEK	22	7,4	1100	0,2
MOUALINE OUED	21,4	7,2	1160	0,3
FDALATE	20	7,2	3000	0,6
AHLAF	20	7,3	900	0,3
SIDI BETACHE	19	7,1	4000	2,2

### Temperature

The results of the temperature of the 15 communes are represented in figure 3.

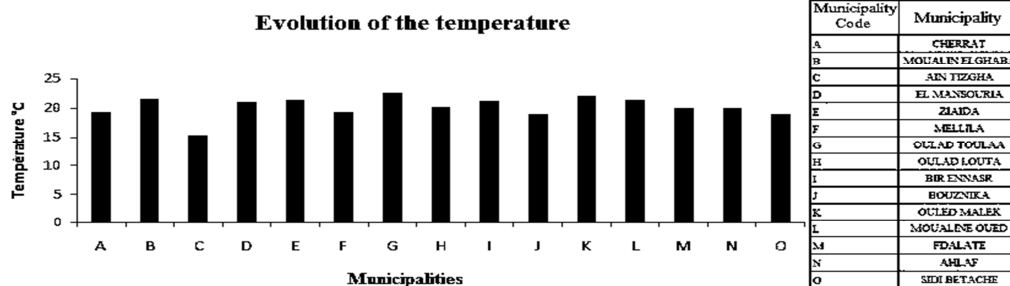


Figure 1: Evolution of the temperature

Note that maximum Temperature is 22.5 ° C and the minimum temperature is 15.2 ° C. These temperatures are acceptable according to the Moroccan standard [3].

This temperature variation is related to the depth of the well, more the well is deep minimum temperature is important and vice versa.

### Influence of pH

The results of the pH of the 15 communes are represented in figure 4.

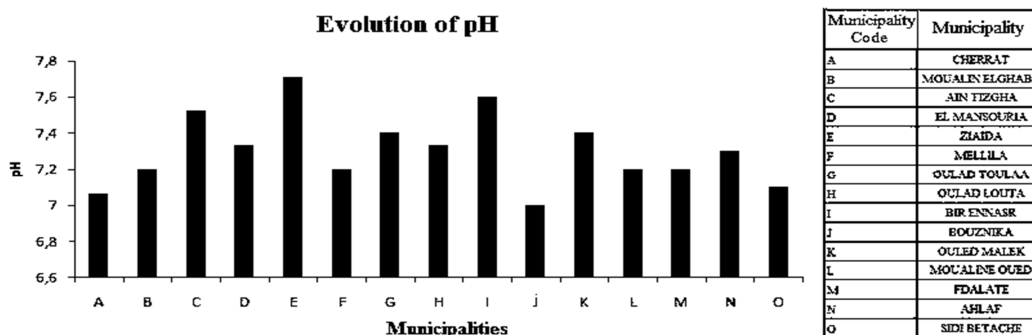


Figure 2: Evolution of pH

Generally the measured pH values are neutral. They are between 7 as Minimum and 7.71 as Maximum, so they are in the majority of groundwater level. Its values are in the field of the Moroccan standard between  $6.5 < \text{pH} < 8$ , 5. These waters are well buffered [3].

### Study of conductivity of water

The results of the conductivity of the 15 communes are represented in figure 5.

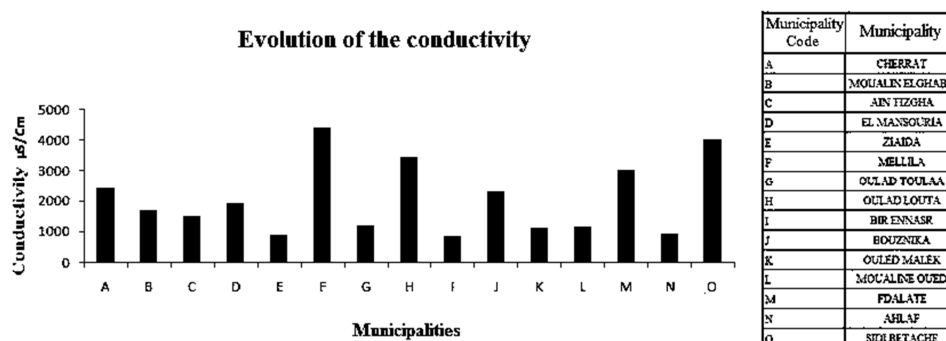


Figure 3: Evolution of the conductivity

Note that Commons MELLILA (4400  $\mu\text{S}/\text{cm}$ ), OULAD LOUTA (3440 $\mu\text{S}/\text{cm}$ ), FDALATE (3000 $\mu\text{S}/\text{cm}$ ) and SIDI BETACHE (4000 $\mu\text{S}/\text{cm}$ ) exceeded the Moroccan standard which is 2700 $\mu\text{S}$  [3].

Moreover the evolution of this setting highlights the role of the effect of the geology on the quality of the water.

This influence is visible at the level of the pit where mineralization is higher in relation to leaching of land surrounding (clayey and sandy terrain).

#### **Inventory of pesticides to agricultural use in the study area:**

With surveys of farmers and the Direction provincial of the Agriculture of BEN SLIMANE allowed us noted that most farmers purchase plant protection products at five retailers in the communes of SKHIRAT and BOUZNKA.

#### **Inventory of pesticides for agricultural and commercial use in the study area**

Surveys conducted in the study area, helped inventory of 63 pesticides agricultural marketed. The main elements of this inventory are as follows:

- 21 insecticides, 9 Herbicides and 33 fungicides with a total of 57 active substances.

#### **The main elements of this inventory**

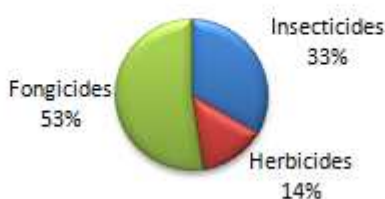


Figure 4: Elements of the inventory

Analysis of the products and their active substances by categories can be:

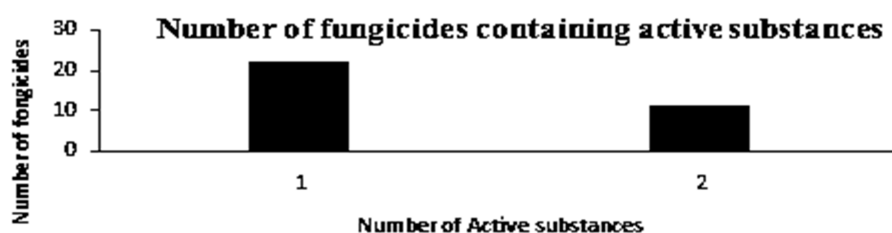


Figure 5: Number of fungicides containing active substances

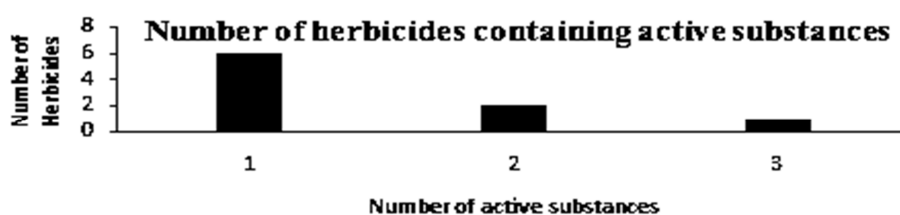


Figure 6: Number of herbicides containing active substances

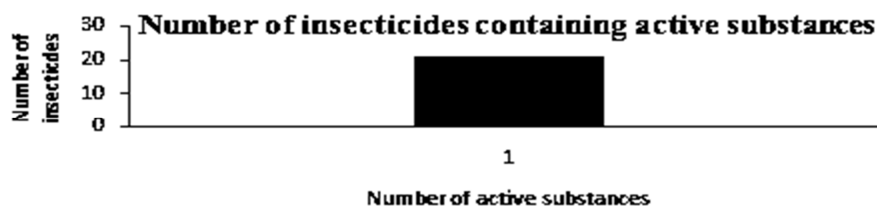


Figure 7: Number insecticides containing active substances

On 33 fungicides 11 fungicides contain 2 active ingredients and 22 fungicides with 1 ingredient active.

On 9 Herbicides 2 Herbicides contain 2 active ingredients, Herbicides 1 which contains 3 active ingredient and 6 Herbicides with 1 active ingredient.

21 insecticides contain 1 active ingredient.

### Major pesticides identified according to risk and toxicological classification:

As reported the danger according to the World Health Organization (WHO) means the degree of risk to health (risk of a single or multiple exposure over a relatively short time) for classifying ecotoxicological and toxicological, the classification of the world Organization of health which was adopted is based on the danger that can constitute a pesticide on human and animal health.

### Case of Insecticides-Acaricides

**Table 6:** Table represents the classification of insecticides-acaricides according to their risk and toxicological

The Active ingredient	Insecticides	Dermal LD50 (mg/KG)	Oral LD50 (mg/KG)	Solubility in water	WHO	Chemical family
DELTAMETHRINE	DECIS EXPERT	> 2000	87	0,005 mg/L	II	PYRETHROID
	SICO-FLUXX					
CYPRENETHRINE	ARRIVO 25 EC	> 2000	287	9 µg/L	II	PYRETHROID
	VITATHRINE					
THIACHLOPRID	CALYPSO 480 SC	> 2000	836 (M) ; 444 (M)	184 mg/L	II	NICOTINOIDE
IMIDACLOPRID	CONFIDOR 200 OD	> 5000	131 (M) ; 506 (F)	601 mg/L	II	NITROGUANIDINE
SPIRODICLOFEN	ENVIDOR	> 2000	> 2500	190 µg/L	III	TETRONIC ACID
GLYPHOSATE	SPEED	> 2000	> 2000	10,5 g/L	III	AMINO ACID
METHOMYL	LANNATE 25 WP	> 1000	20 (M) ; 28 (F)	58 g/L	Ib	CARBAMATE
ABAMECTINE	VALMEC	330	10	nn sol	III	AVERMECTIN
	TINA					
FENAZAQUIM	PRIDE 200 SC	> 5000	134	130 µg/L	II	QUINAZOLINE DERIVATIVES
TAU-FLUVALINATE	MARVIK 2F	> 2000	282 (M) ; 261 (F)	1,03 µg/L	II	PYRETHROID
ALPHACYPERMETHRINE	CONCORD 100 EC	> 2000	57	3,97 µg/L	II	PYRETHROID
TEBUFENPYRAD	MASAI	> 2000	320	2,4 mg/L	III	PYRAZOLAMIDE
PYRIDABEN	NEXTER 10 SC	> 2000	435 (M) ; 358 (F)	12 µg/L	III	PYRIDAZONE
PROPAGITE	OMITE 570 EW	4000	2800	632 mg/L	III	
DIMETHOATE	PERFEKHION	> 2000	245	39,8 g/L	II	ORGANO-PHOSPHORUS
BIFENTHRINE	TALSTAR	> 2000	54,5 (M) ; 186,1 (F)	< 0,001 mg/L	II	PYRETHROID

### Case of Herbicides

**Table 7:** Table represents the classification of Herbicides according to their risk and toxicological

The Active ingredient	Herbicides	Dermal LD50 (mg/KG)	Oral LD50 (mg/KG)	Solubility in water	WHO	Chemical family
2,4 - D	AL FAHD MIX	> 2000	764	34 g/L	II	ARYLOXYACIDE
	YEDESTER 225					
	U 46 COMBI FLUID 6					
2,4 - MCPA	U 46 COMBI FLUID 6	>1000	700		III	
	AL FAHD MIX					
FORMASULFRON	MAISTER OD	> 2000	> 5000	37 mg/L	III	SULFONYLUREE
iodo SULFRON-METHYL-SODIUM	MAISTER OD	> 2000	2678	25g/L	III	UREA
ISOXADIFEN-RTHYL	MAISTER OD	> 2000	1611	1,06 mg/L	III	-----
BENTAZONE	BASARGAN	> 5000	1800	570 mg/L	III	THIADIAZIME
DIMETHERAMIDE	INTEGRITY	> 2000	371	1,45 g/L	III	CHLOROACETAMIDE
PENDIMETHALINE	PROWL	> 2000	> 5000	0,33 mg/L	III	DINITROANILINE
NICOSUFLURON	NICOSH 750 WG	> 2000	> 5000	7,5 g/L	III	SUFLONYLUREE
GLYPHOSATE	ROUNF UP	> 2000	> 2000	10,5 g/L	III	ACIDE AMINE

## Case of fungicides

Table 8: Table represents the classification of fungicides according to their risk and toxicological

The Active ingredient	Fungicides	Dermal LD50 (mg/KG)	Oral LD50 (mg/KG)	Solubility in water	WHO	Chemical family
THIRAME	THIRAMIC	> 2000	3700 (M) ; 1800 (F)	0,0165g/L	III	CARBAMATE
	BASULTRA					
CHLOROTHALONIL	BAKALA	> 2000	> 5000	0,81mg/L	III	ISOPHTALOMITRILE
	CLORTOSIP					
BUPIRIMATE	NIMROD 25 EC		4000	13,06mg/L	III	PYRIMIDINE
DIFENOCONAZOLE	PRIORITOP	2010	1453	15mg/L	III	TRIAZOLE
	DIFCOR 250 EC					
	SCORE 250 EC					
BOSCALIDE	COLLIS SC	> 2000	> 5000	4,64mg/L	III	CARBOXIME
	SIGNUM WG					
KRESOXIM-METHYL	COLLIS SC	> 2000	> 5000	2mg/L	III	STROBILURIME
	ALLERGO					
PROPINEBE	ANTRACOL COMBI	> 5000	> 5000	< 0,01g/L	III	CARBAMATE EDBC
	ANTRACOL 70 WP					
OXYCHLORURE DE CUIVRE	FLARE GOLD	> 2000	1862	< 0,312 mg/L	III	MINERAL
METALAXYL-M	FLARE GOLD	> 2000	953 (M) ; 375 (F)	26g/L	III	PHENYLAMIDE
	RIDOMIL GOLD MZ 68 WC					
MANCOZEBE	AGRIZEB 80 WP	> 2000	> 5000	2 - 20mg/L	III	CARBAMATE EDBC
	ACROBAT					
	TURBO ZM					
	RIDOMIL GOLD MZ 68 WC					
PROPAMOCARBE	PROPLANT	> 2000	> 2000	500g/L	III	CARBAMATE
	CONSENTO					
HEXA CONAZOLE	HEXA 5 SC					
AZOXYSTROBINE	ZEBRA 320 SC	> 2000	> 5000	6,7mg/L	III	STROBILURIME
	PRIORITOP					
PENCONAZOLE	TOPAS 100 EC	> 3000	2125	0,073mg/L	III	TRIAZOLE
MYCLOBUTANIL	SYSTHANE 240 EC	> 2000	1600 (M) ; 2290 (F)	132mg/L	III	TRIAZOLE
DIMETHOMORPHE	ACROBAT	> 2000	> 5000	0,0107g/L	III	ACIDE ANNAMIQUE
	CABRIO DUO					
	ORVEGO					
EPOXICONAZOLE	ALLERGO	> 2000	> 5000	8,4mg/L	III	TRIAZOLE
	OPERA MAX					
BOCALID	BELLIS WG	> 2000	> 5000	4,64mg/L	III	CARBOXIME
PYRACLOSTROBINE	BELLIS WG	> 2000	> 5000	1,9mg/L	III	STROBILURIME
	OPERA MAX					
	SIGNUM WG					
	CABRIO DUO					
SOUFRE MOUILLABLE	KUMULUS DF	> 2000	> 2000	63µg/L	III	MINERAL
AMETOCTRADINE	OVERGO	> 2000	> 2000	0,23mg/L	III	UNSPECIFIED
TEBUCONAZOLE	ZEBRA 320 SC	> 2000	1700	36mg/L	III	TRIAZOLE
	KING 250 EW					
PHOSETHYL ALUMINIUM	ALIETTE FLASH	> 2000	5800	120g/L	III	
CYMOXANIL	ANTRACOL COURBI	> 2000	960	780mg/L	III	UNSPECIFIED
FENAMIDONE	CONSENTO	> 2000	> 5000	7,8mg/L	III	IMIDAZOLINE
TRIFLOXYSTROBINE	FLURT	> 2000	> 5000	0,62mg/L	III	STROBILURIME
CYCLOXYDINE	FOCUS ULTRA	> 2000	4420	40mg/L	III	CYCLOHEXANEDIONE

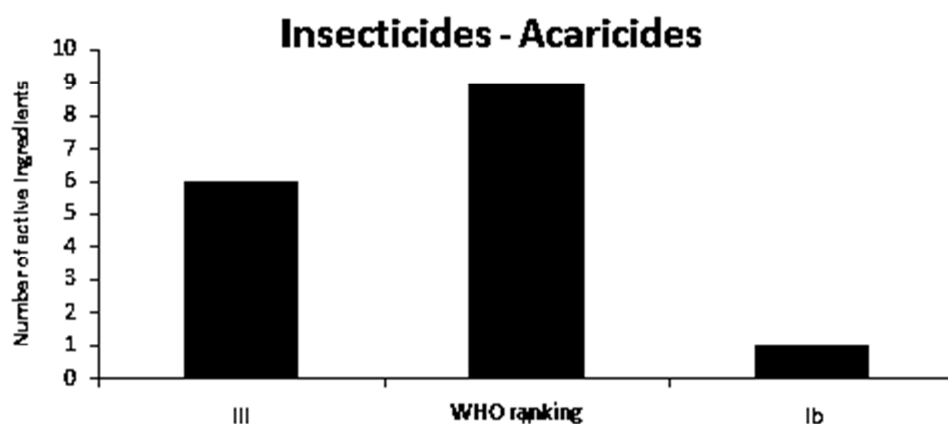


Figure 8: Number of active ingredients in each ranking for (WHO) for insecticides and acaricides

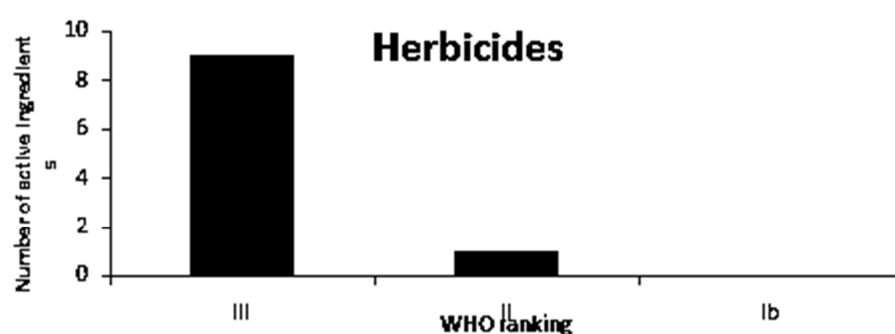


Figure 9: Number of active ingredients in each ranking for (WHO) for herbicides

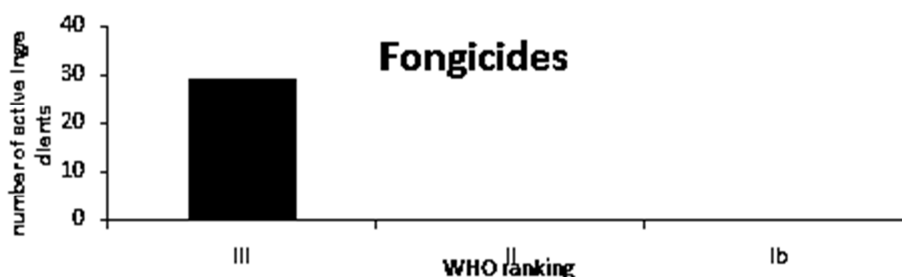


Figure 10: Number of active ingredients in each ranking for (WHO) for fungicides

The insecticides used in the study area contain a most dangerous active substance (class Ib), 9 of moderately dangerous substances (class II) and 6 slightly hazardous substances.

For herbicides are poorly used in the study area, there are 9 slightly dangerous active substances (class III) and 1 moderately dangerous substance (class II).

In addition, fungicides despite their high number, they contain class III which is slightly dangerous products [4].

#### **Toxicity of active substances identified in the study area:**

The list of compounds identified as the most toxic during the inventory of pesticides for use in agriculture is represented by 9 active substances: Methomyl, deltamethrin, Cypermethrin, Thiacloprid, Imidacloprid, Tau-fluvalinate, Dimethoate, Bifenthrin, 2,4-d.

After the study of the toxicity of its active ingredients there is that the effects on the various components of the ecosystem are:

- For mammals including man:

Acute toxicity: very toxic waterway oral and ocular and moderately toxic by inhalation, irritating to eyes

Long-term toxicity: neurologic effects, lose weight, stimulation of the nervous system

- Toxicity to non-target species:

Toxic to non-target fish or Daphnia, bird and bee oral or bioaccumulation species.

- The behaviour in environmental fate:

Risk of contamination of groundwater and surface water by leaching and runoff, great half-life and poorly soluble in water and degraded by biodegradation, hydrolysis or photolysis and absorbed by sediment.

Pesticides are designed to kill "pests", but some pesticides can also have adverse effects on the components of the ecosystem. The likelihood of suffering adverse effects depends on the type of pesticide and other chemicals it contains, the duration and the frequency of exposure.

Some adverse health effects due to exposure to a pesticide can be felt immediately. Some symptoms may occur several hours after exposure. Other effects may occur after several years, for example cancer.

Some symptoms due to exposure to a pesticide shall cease at the end of the exhibition. Others may take some time to disappear. People regularly exposed to pesticides, long term health effects are more worrying.

### CONCLUSION

This research allowed us to make a study of pesticide inventory in BEN SLIMANE province and also to control the quality of groundwater, to analyze some physicochemical parameters to clear interactions between agricultural use pesticide and environment.

Inventory has found 63 agricultural pesticides marketed, including 21 Insecticides, 9 Herbicides and fungicides 33 with a total of 57 active substances, which belongs to the different level of toxicity report by the World Health Organization. Hence it has noted certain risks related to these substances (active substances), particularly plant protection products whose active substances belong to class Ib and II which represent a potential hazard on the various components of the ecosystem and requiring a follow-up in the future in the various components of the ecosystem come water, soil, plant and animal information METHOMYL, DELTAMETHRIN, CYPERMETHRIN, THIACLOPRID, TAU-FLUVALINATE, DIMETHOATE, IMIDACLOPRID, BIFENTHRIN, 2,4-d that on a great impact on mammals including humans, toxicity to non-target such as Daphnia, birds, bees fish species, and also a great impact on the environment where there is a great persistence and leaching potential, therefore a contamination of surface and groundwater.

### Acknowledgements

It is essential to deepen the study and gather more information on the quality of groundwater in the province and particularly the level of contamination of these ecosystems by elements particularly traces the heavy metals and pesticides and to study the risks associated with their presence, because the inhabitants of the province of BEN SLIMANE rely mainly on groundwater for water.

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