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IMPACT OF INDUSTRIAL POLLUTION GENERATED BY TWO COMPANIES (THEAZAZGA - ELECTRO INDUSTRIES AND THE NATIONAL COMPANY OF INDUSTRIES ELECTRO- MENAGER OF OUEDAISSI) ON THE SOIL FAUNA

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ABSTRACT

We have undertaken a study on the impact of industrial pollution of the final discharge of two large industrial companies in the wilaya of Tizi -Ouzou (Algeria) on the pedofauna. This is about the Electro Industries of Azazga and the National Company of Industries appliances Oued Aissi. We opted for the method of the quadra (25 × 30 cm) with three depth levels N_1 (0-10 cm), N_2 (10-20 cm), N_3 (20-30 cm) during three seasons (winter, spring and summer). The extraction of the soil organisms is achieved by the simplified technique of Berlese Tulgrene. The gathered animals are sorted, identified and counted. In addition to the inventory, analyses are performed on the ground such as granulometry, pH, O.M. and the determination of heavy metals. The identified wildlife is divided into 18 levels divided into 60 families and 102 species with the apparent action of the season, the depth and the pollution thanks to gastropods which are bio - indicators.

KEYWORDS: Soil, Pedofauna, Industrial Waste, Pollution, Indicator Species

INTRODUCTION

With the scale of population growth and the improvement of the standard of living that our planet has known over centuries, the effects of industrialization are revealed catastrophic for living beings, including humans.

The pollution caused by human activities (agriculture, industry,) on or in the soil, is directly or indirectly harmful to the soil quality (NICOLAS, 1997). The evaluation of this quality is done by chemical, physical and biological indicators which are more sensitive for the process of planning and disturbances.

This is why the protection of various components of the environment and biodiversity constitute real challenge for our society; it's for this that practical and legal measures of conservation of the environment are put in place in the context through a sustainable development (YAAKOUBI &*al*., 2009).

It is in this context that we are interested in studying the impact of industrial pollution of the final rejection of two companies that are Azazga Electro Industries and ENIEM. Of OuedAissi on soil organisms because the ground is one of the most important reservoir of biodiversity that corresponds several times to that of observed above the ground surface (HEYWOOD, 1995). The goal is to research in the soils of these companies, bio- indicators t go permits greater appreciation of this pollution

To well answer this theme, we opted for a comparison of the soil of a fauna of a polluted site (soil companies) and other healthy (a distance of about 1km from the first and located at a slope.) while achieving physical analysis of soils at both sites and chemical analysis including heavy metals.

MATERIAL AND METHODS

In Algeria, it is in the North that the industrial potential and their industrial pollution sources are located. Our choice was, in the wilaya of Tizi-Ouzou (located 100 km east of Algiers), two companies that are Electro-Industies Azazga (EI), specializing in the manufacturing and marketing motors, transformers and generators, and the national company of the appliance industry (ENIEM.) of Oued Aissi who is known for manufacturing and assembly of appliances namely refrigerators, stoves, heaters, bathroom heaters, etc.

Our sampling in this area is random. It is based on the method of quadrat that allows us to take a sample each month (December to August) with a sampling level of 0-30 cm in three levels:

- The first level (N1) corresponds to layer 0 to 10 cm deep,
- The second level (N2) corresponds to the 10 to 20 cm depth of layer,
- The third level (N3) corresponds to the 20 to 30 cm depth of layer.

Healthy soil analyses of the two study sites were carried out, namely the size, pH, lime, organic matter, and chemical analyzes of heavy metals such as Lead, Chromium, Zinc, Cadmium, Copper, Aluminium and Silver.

The extraction of soil microorganisms consist of separating them from the substrate through the extractor Berlese-Tullgren simplified by dry way, after collecting all the fauna visible to the naked eye. Once harvested soil fauna is sorted, identified and counted, the results are subject to environmental analysis and comprehensive statistics (specific richness, abundance, dominance, index of Shannon-Weaver, equitability, variaty analysis, principal component analysis, factor analysis of correspondence and correlation).

RESULTS AND DISCUSSIONS

Soil Analysis of Both Sites

The results of soil and physical-chemical analysis performed on the soil samples from both study sites, are shown in Tables 1 and 2.

Table 1: Results of Soil and Physical-Chemical Analysis Performed on Soil Samples from Both Study Sites, Are Shown in Tables 1.2

Soil		Physical Analysis						Chemical Analysis						Texture
		A%	LF%	LG%	SF%	SG%	pH	$CACO_3$ Total	$CACO_3$ Actif	C.E ds/cm	C Total	M.O	H%	
E.I.	Healthy	39	L.A.	28,8	3,97	19,16	7,8	3,2	--	1,9	4,63	7,96	1,6	Siltyclay
	Polluted	25	L	38,8	6,2	22,4	7,5	16,62	5	2,1	10,33	17,76	0,01	Silty
ENI	Healthy	22,5	16	41,6	8,16	11,6	8,2	9,7	7,1	2,3	2,10	3,61	3,3	Silty
EM	Polluted	23,5	15	40	9,5	11,9	8,3	8,9	2,1	1,8	2,31	3,97	3,02	Silty

The physicochemical characterization of soils of IE (Table 1) allowed us to distinguish healthy soil silty clay texture, alkaline pH, and low salt and low limestone around 3 and well supplied with organic matter. It is occupied by natural vegetation of grasses. While the polluted soil is loamy texture, pH neutral, moderately salty and limestone. This floor is fitted with dense, deep roots and is very well supplied with organic matter, which explains its black color. In general, these soils are heavy, which forms an obstacle to a good permeability to water and air.

Soils of the ENIEM. Are of siltytexture that it is healthy (citrus fields) or the polluted which is occupied with natural vegetation and a dense network of grasses (reed) that reflects its pollution. These are slightly salty soils, brown in color, well supplied with organic matter, with an alkaline pH. They are moderately limestone, allowing the formation of aggregates which facilitate the circulation of water and nutrients substances.

According to the results of Table 2, we notice that the contents of polluted soils of both heavy metal sites are high. The polluted soil of IE is richer in copper and especially mercury. Than that of the ENIEM. It is also noticed that the healthy soil of ENIEM is quite supplied with heavy metal.

Table 2: Results of Heavy Metal Analyzes of Soil from E.I. and of ENIEM

Stations	Samples	Pb	Cr	Zn	Cd	Cu	Al	Hg
	mg/kg						g/kg	µg/kg
ENIEM.	Healthy soil	33,6	45,4	90,9	<3	26,2	4,5	1109
	Contaminated soil	34,8	47,1	94,3	< 3	27,2	11,9	1281
EI.	Healthy soil	< 20	< 20	< 3	<3	66	9,6	470
	Contaminated soil	33,6	48,4	70,6	< 3	89,9	14,6	3842

According to the results in Table 2, we notice a significant difference between healthy soils and polluted at the EI. where the heavy metal content is higher in the polluted soil (Pb = 33.6 mg, 48.4 mg = Cr, Zn = 70.6 mg) compared to the healthy soil (Pb and Cr < 20 mg Zn < 3mg). Whereas at the ENIEM. The results of heavy metal analysis show no significant difference between healthy soil and the polluted soil (Pb = 33.6 and 34.8 mg Cr = 45.4 and 47 1 mg, Zn = 90.9 and 94.3 mg for healthy soil than the polluted). The presence of heavy metals in soils is particularly problematic because of their non - biodegradability and toxicity (BERKOUKI, 2011).

Analysis of the Fauna of the Two Sites

We were able to identify 18 orders distributed on 60 families and 102 species. At EI. a total of 59 species was collected in healthy soil against 67 in the polluted soil. At ENIEM. A total of 59 species was collected in healthy soil against 47 species in the polluted soil (Table 3).

Table 3: All Faunal Groups Identified in the Study Sites

Groups	Annelids	Arachnids	Springtails	Shellfish	Gastropods	Insects	Myriapods
Orders	1	2	3	1	1	8	2
Families	1	9	7	2	6	30	5
Species	1	18	18	4	9	52	6

According to Table 3, the fauna of our study area is represented by insects, springtails, arachnids, gastropods, Myriapods, crustaceans and annelids. The insect class is the most dominant with 52 species. It is followed by springtails and arachnids with a total of 18 species.

During our sampling at the level of healthy and polluted soils of EI. we have collected a total of 770 individuals in healthy soil and 1534 individuals in the polluted soil whose proportions are shown in Figures 1 and 2.

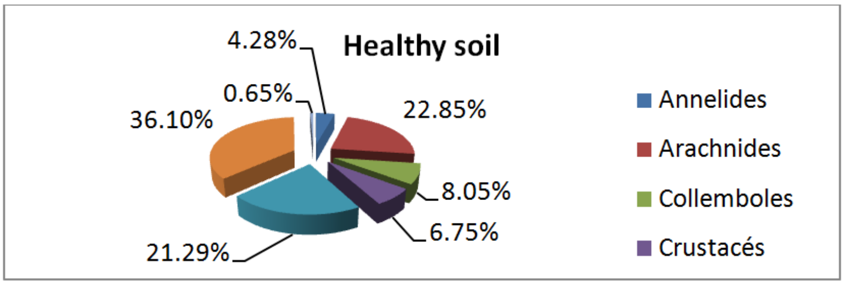

Figure 1: Relative Abundance of Faunal Groups Identified in the Healthy Soil of EI

From Figure 1, the healthy soil of EI. Is represented firstly by Insects with a rate of 36.10%, followed by the Arachnids with 22.85% then gastropods with 21.29%, while Collembola and Crustaceans represent only 8.05% and 6.75% respectively.

From Figure 2, the polluted soil of EI. Shows significant dominance of gastropods with a rate of 69.36 % and 12.25 % with the Arachnida. Finally, annelids, Myriapoda and Crustaceans are poorly represented with respective rates of 3.58 %, 1.62 % and 0.72 %.

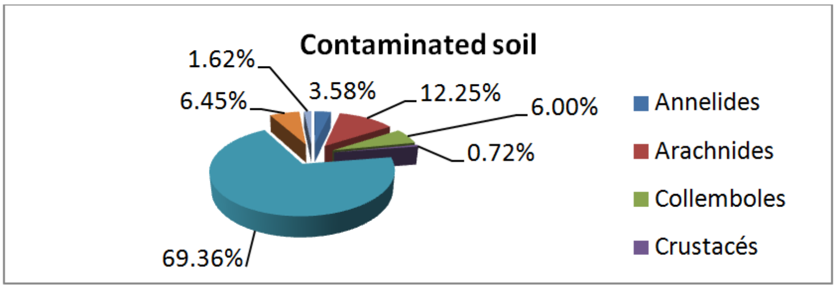

Figure 2: Relative Abundance of Faunal Groups Identified in the Polluted Soil of EI

In the soils of ENIEM. We have collected 951 individuals in healthy soil and 399 individuals in the polluted soil whose proportions are shown in Figures 3 and 4.

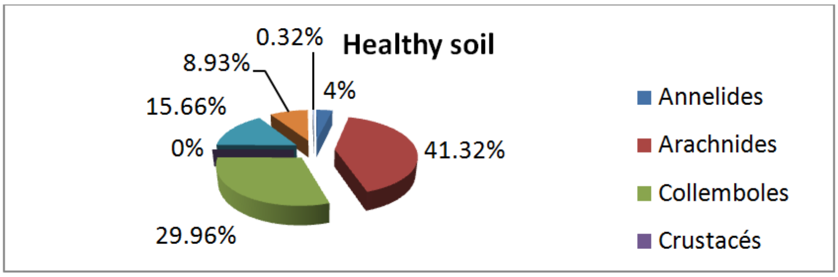

Figure 3: Relative Abundance of Faunal Groups Identified in the Healthy Soil of ENIEM

From Figure 3, the witness soil of ENIEM. Contains Arachnids as a dominant group with a rate of 41.32 % followed by Collembola with 29.96% and 15.66% with gastropods. We note, however, the lack of Crustaceans.

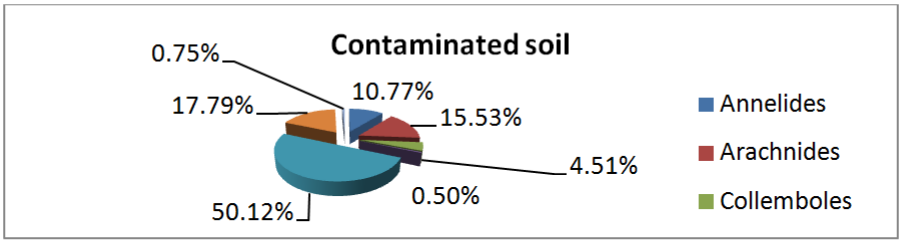

Figure 4: Relative Abundance of Faunal Groups Identified in the Polluted Soil of ENIEM

From Figure 4, the polluted soil of ENIEM. is characterized by the dominance of gastropods with a rate of 50.12 %, followed Insects and Arachnids with rates of 17.79 % and 15.53 %. Very low rates are observed for the Myriapods (0.75%) and the Crustaceans (0.50 %).

Effect of the Season and Depth

Figures 5 and 6 show the richness of soil temoin and polluted soils of the EI. And of ENIEM. According to depth during the different seasons.

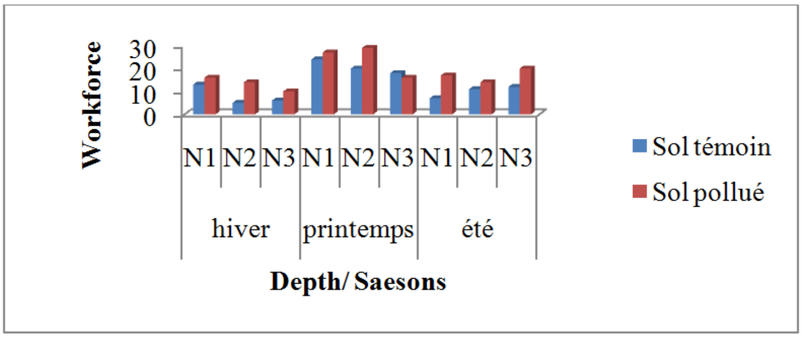

Figure 5: Specific Richness of EI. According to Season and Depth

At EI. Analysis of specific richness (Figure 5) shows that the polluted soil is richer in species than the healthy soil during three seasons and depending on the depth where the number of species decreases from the level 1 to level 3. the maximum richness is observed in spring with a peak of 29 species in level 2 corresponding to the depth 10-20 cm and the weakest richness (5species) is recorded in the healthy soil during the winter in level 2.

In Figure 6, we notice that specific richness is more important in the ENIEM. Healthy soil than in the contaminated soil especially in spring with a record peak of 29 species. This fauna is mainly more abundant in level 2 of the soil corresponding to the depth 10-20 cm.

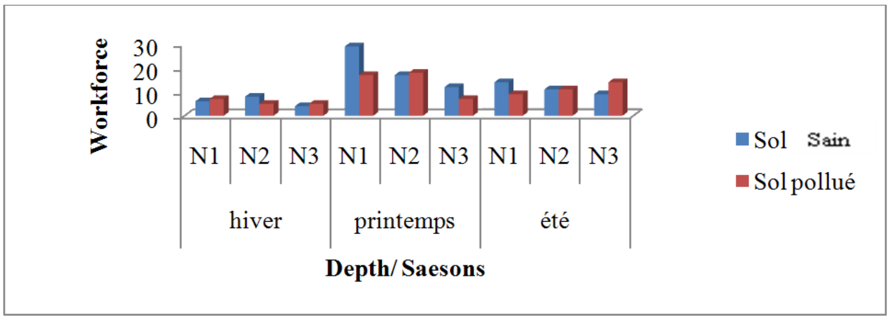

Figure 6: Specific Richness of ENIEM

This richness is expressed by a set of species shown in Figures 7, 8, 9 and 10.

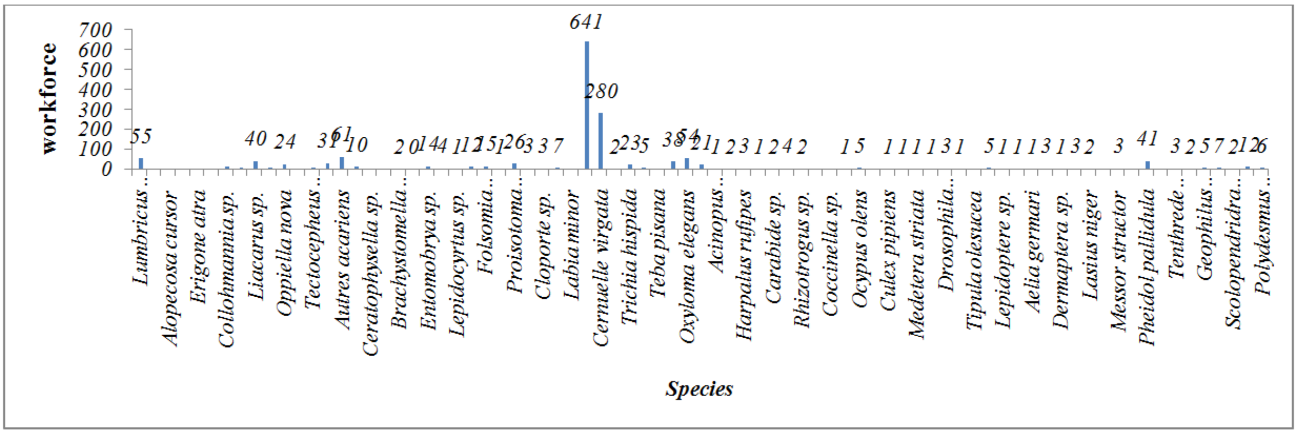

Figure 7: Species Inventoried Soil Fauna in the Polluted Soil of EI

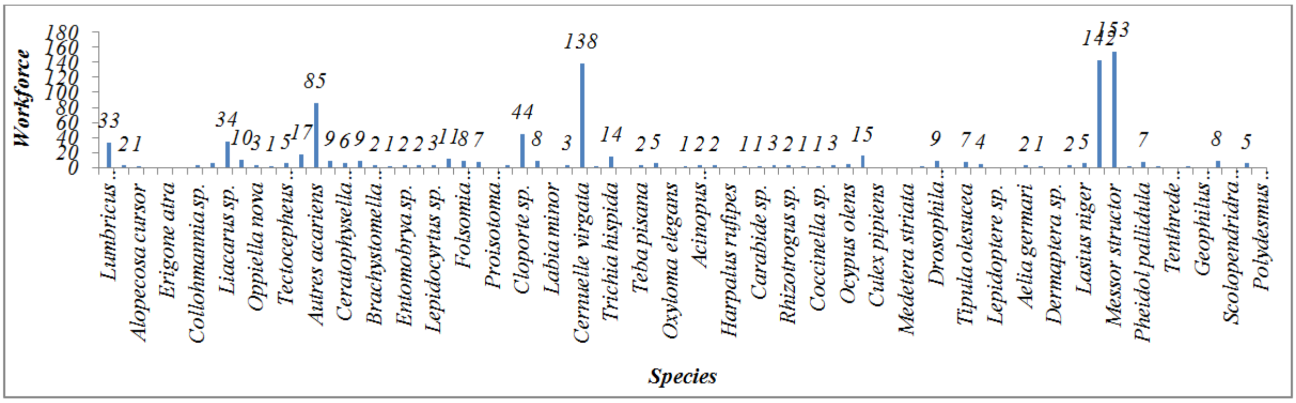

Figure 8: Species of Soil Organisms Inventoried in the Healthy Soil of EI

According to figures 7 and 8, we identify a specific richness of 59 species in the healthy soil and 67 species in the polluted soil at the EI. In healthy soil (Figure 8), we notice plenty of *Messor structor* with 153 individuals, *Liasus Niger* represented by 142 individuals and 138 individuals presented in *Cernuella virgata*. In the polluted soil we notice remarkable abundance of gastropods such as *Cernuella virgata* represented by 641 individuals, with 280 individuals *Trichia hispida* and *Teba Pisana* which represents lower work force of 54 individuals.

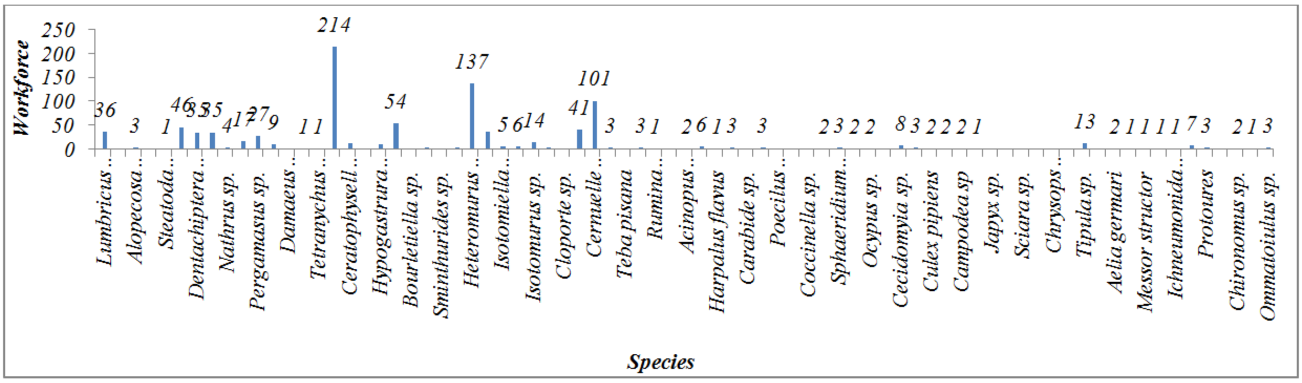

Figure 9: Species of Soil Organisms Inventoried in the Healthy Soil of ENIEM

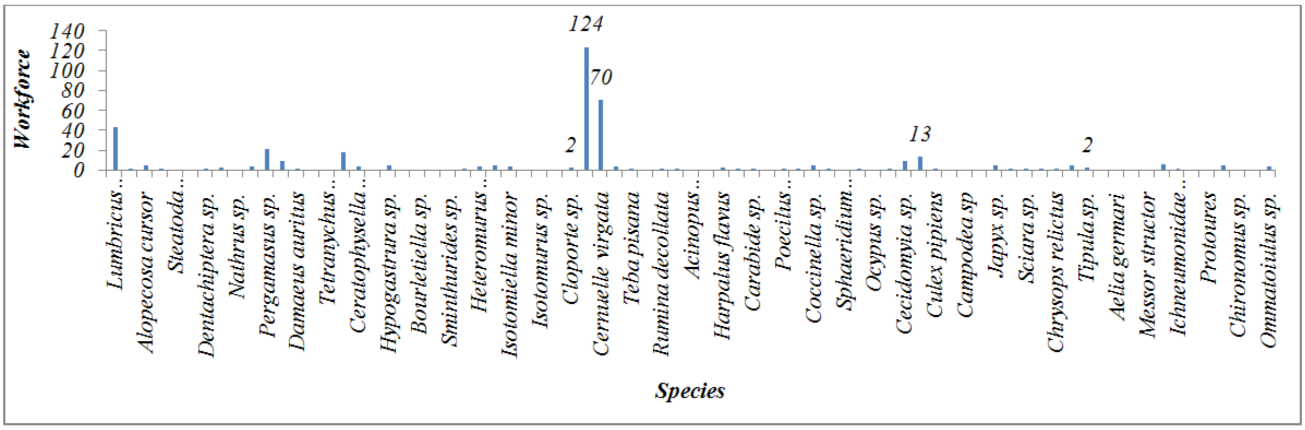

Figure 10: Species Inventoried Soil Fauna in the Polluted Soil of ENIEM

According to figures 9 and 10 we identify a specific richness of 59 species in the healthy soil and 47 species in the polluted soil of ENIEM. We find that these organism depend on their environment by the availability of some soil factors mainly moisture, structure, organic matter and pH. In all the samples studied we obtained the most important variable rates in healthy soil represented by *Tetranychus cynabarimus* (214 individuals), *Heteromerus major* with 137 individuals and 101 individuals with *Cernuella virgata*. In the polluted soil, the proportions of the majority of species is low with the exception of gastropods including species *Cernuella virgata* (124 individuals) and *Teba Pisana* (70 individuals) not to mention the high rate of *Lumbricu sterrestris* which is 43 individuals.

STRUCTURE AND COMPOSITION OF SOIL FAUNA INVENTORIED AT BOTH SITES

Berger- Parker Dominance

The dominance of Berger -Parker (BP) of studied stations (Table 4) is higher in polluted soils than in healthy soil with a maximum value of 0.41 in the polluted soil of EI. It is characterized by the dominance of ants especially *Lasiussp* with a workforce of 153 individuals in healthy soil and the dominance of gastropods represented by *Cochlicella barbara*with 641 individuals in the polluted soil of EI. At the level of ENIEM. This dominance is expressed by the group of Collembola species including *Heteromerus major* with 137 individuals in healthy soil and the dominance of gastropods represented by *Cochlicella barbara*with 124 individuals in the polluted soil.

Table 4: Dominance Berger-Parker Studied Stations

Companies	Healthy Soil	Contaminated Soil
EI.	0.17	0.41
ENIEM.	0.14	0.31

Shannon -Weaver Index (H')

We opted for the calculation of the Shannon-Weaver diversity index to highlight the relative abundance of different taxa, this is why we have separately calculated it For the healthy soil and the polluted soil. The obtained results are translated in figures 11 and 12.

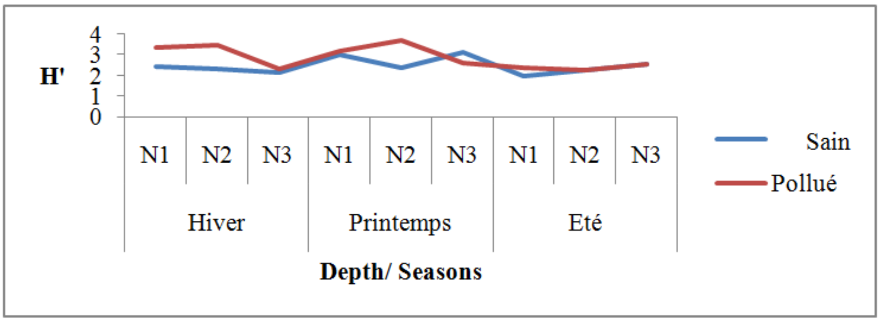

Figure 11: Shannon -Weaver Index for the Soil of the EI

It emerges from figure 11 that at the level of EI. The Shannon index (H') is variable with a maximum of 3.67 in the polluted soil and a minimum of 1.96in the healthy soil.

The highest values are recorded in the polluted soil due to the great richness of the rejection of EI. in organic matter whereas in the healthy soil, H' values are below 3 what convey an average diversity of populating with a good representation of same taxa. This index is important in level 1 of the healthy soil, whereas in the polluted soil, H' is more important in level 2. Shannon index is highest during spring in comparison to other seasons be it in the healthy soil or in the polluted soil.

At the ENIEM. The results in Figure 12 show that Shannon index (H ') varies with a maximum of 3.67 in the healthy soil and maximum of 2 in the polluted soil. The values of H' recorded in healthy and polluted soils are nearer; because of met pollution, they are more important during spring in level 2 for the two soils; healthy and polluted.

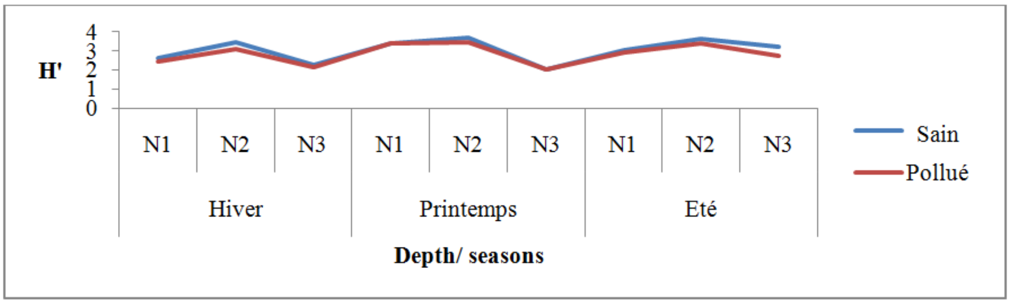

Figure 12: Shannon -Weaver Index for the Soil of the ENIEM

Equitability

The Equitability or relative diversity index is calculated for both stations (EI and ENIEM.) and the results are shown in Figures 13 and 14.

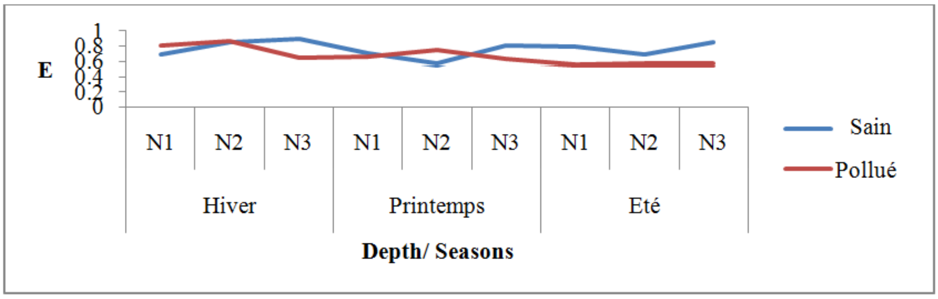

Figure 13: Equitability in the Soil of EI

According to Figure 13, we notice that the Equitability is less than 1 be it in the healthy or the polluted soil. The peak is at 0.89 in the healthy soil during the winter and the minimum is 0.55 in the polluted soil during the summer. This Equitability is higher in level 2 of the polluted soil and level 3 of healthy soil which expresses a very important faunal diversity.

In Figure 14, we notice that the Equitability reached a peak of 0.95 in healthy soil during summer and a minimum of 0.52 in the polluted soil during spring. This index is important in level 2 for both soils, which expresses their diversity and species richness.

In healthy soil, equitability index of PIELOU (1966) is relatively high, what stipulates the balance between species. Nevertheless, the equitability index for the polluted soil is smaller, suggesting that there is certainly a dominant species. It's the case of gastropods (*Cochlicella barbara* with 641 individuals).

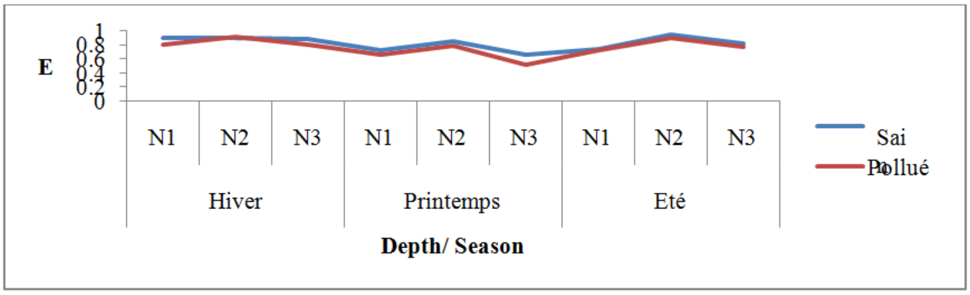

Figure 14: Equitability of the Soil of ENIEM

Profit for the ACP

Station 1(EI)

Given the interpretation of the axes, the cloud structure of the statements obtained by the ACP. can be summarized in a fairly well expressed gradient along the axis 1 and perfectly assimilated to the negative action of the combined pollution to gastropods in relation to other faunal groups identified that signify their bio-indication, as it shows correlations between the wildlife groups and the environmental factors (Figure 15).

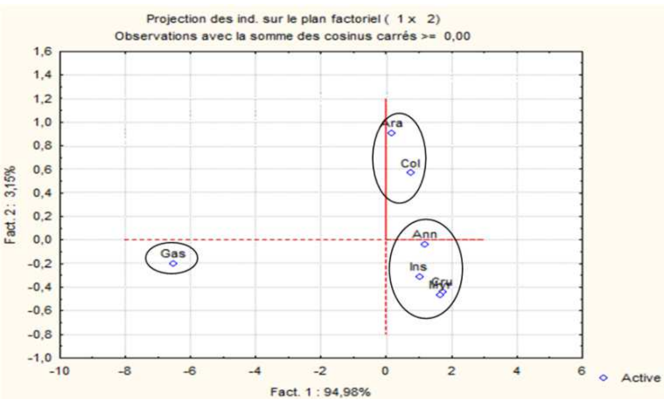

Figure 15: ACP. Representative of the Distribution of Wildlife Groups Harvested from the Polluted Soil of EI

Through Figure 15 we notice the resistance of gastropods against pollution, which makes them polluo - resistant species, while other faunal groups are polluo - sensitive. This is directly related to the depth that has a significant effect especially Annelids, Insects and Millipedes that migrate deep seeking favourable conditions for their survival following the seasonal pattern. Concerning the Collembola and the Arachnids they are affected, by the negative action of pollution and depth.

Station 2 (ENIEM)

Given the interpretation of the axes, the cloud structure of the statements obtained by the CPA. can be summarized in a fairly well expressed gradient along the axis 1 and perfectly assimilated to the negative effect of pollution on both soils healthy and polluted with the location of gastropods and Arachnids on the negative position with respect to other faunal groups identified (Figure 16).

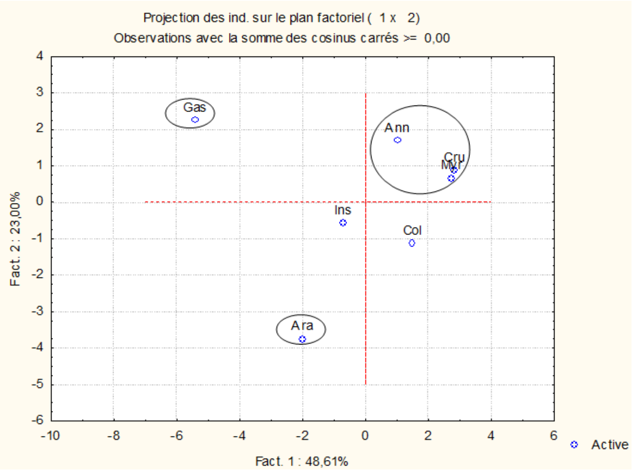

Figure 16: ACP. Representative of the Distribution of Wildlife Groups of ENIEM Harvested

Figure 16 distinguishes faunal groups according to different environmental factors such as gastropods which indicate pollution, the Annelids, the Crustaceans and Millipedes are influenced by the depth, while the rest of the groups are sensitive to seasonal variations according to the depth and the presence of pollution.

Results of the AFC

The spatial distribution of species is specified by a correspondence analysis (AFC.) executed on the matrix level species × (18 × 79espèces levels).

The two first axes accumulate 61.4% of inertia contained in the data matrix (F1 = 60%, F 2 = 1.4%).

Given the objectives of this study, it was not essential to determine the exact meaning of each axis, but rather to differentiate the consistent groups of species in terms of their ecology; then from the two axes (F1 × F2) we have distinguished the following groups:

- **Group A:** includes the susceptible species to pollution in the positive direction especially Collembola*as Isotomiella minor, Entomobrya sp, Heteromurus major, Cryptopygus thermophilus, Proisotoma minuta and same insects such as Culex pipiens, Harpalus sp,...*
- **Group B:** includes species that tolerate and resist pollution in the negative sense as *Messor structor, Drosophila melanogaster, Japyx sp, Alopecosa cursor, Ommatoiulus sp, Lumbricus trrestrice, but especially gastropods as Cochlicella barbara, Cernuella virgata, Trichia hispida, Trochia pyramidata, Teba pisana, Rumina decollate...*

The results of this factorial plan confirm positive and negative correlations presented by the two significant axes of the effect of pollution on species.

The first two axes accumulate 72% of inertia contained in the data matrix (F1 = 44 %, F2 = 28%).

From the two axes (F1 × F2), we have distinguished the following groups:

- **Group A:** comprises the majority of species of gastropods in the negative direction as *Cochlicella barbara*, *Cernuelle virgata*, *Trichia hispida*, *Trochia pyramidata*, *Teba Pisana*, *Rumina decollata*...
- **Group B:** includes the acarid species in the positive direction as *Nathrus sp*, *Pergamasus sp*, *Liacarus sp*, *Damaeus auritus*, *Tetranychus sp*, *Tectocepheus velatus*...

The results of this factorial plan confirm the positive and negative correlations presented by the two axes of the significant effect of pollution on species and the degradation of the ecosystem.

DISCUSSIONS

The results of the analysis studied soils have shown that they are loamy, rich in limestone and organic matter, alkaline pH, with high levels of heavy metals in polluted soils due to the storage of waste in the open air and directly on the ground without preliminary precautions and this at both companies. Added to this, the basin discharges of toxic products such as cyanide already made at this level as well as the rejecting of stations and failing purification are rich in metals and used by farmers in the region to water their citrus fields for generations according to the testimony of the owners.

The results obtained in ENIEM., greater faunal richness in healthy soils than in polluted soils. This fauna is characterized by the dominance of gastropods, which are, according CORTET &*al.*, (1999) biological indicators of pollution and confirmed by DECAENS &*al.*, (2006) as being bio-indicators of soil quality or pollution. They are also heavy metals bio-accumulators and show a preference for calcareous soils (BACHELIER, 1978). However at the EI., faunal richness is higher in polluted soil because of the high humidity and the high rate of organic matter provided by the industrial waste also with the dominance of gastropods which are abundant in wet litter. These are primary consumers of soil organic matter (BACHELIER, 1978) and according to MOUTHON (1980), a moderate environmental enrichment in organic material causes, without reduction in specific richness, a remarkable increase in the density of most species revealing their high degree of saproting. Therefore gastropods have a real "strategy" of adaptation to the environment and the course of their life cycle is under the close dependence of environmental factors such as temperature, the trophic conditions... and can vary sensibly from one species to another. This adaptive plasticity allows the species to have maximum productivity in given conditions and thus offset from one year over another the low productivity due for example to a severe winter. It may be noted also the selective advantages of an annual cycle in gastropods in which adults that disappear after laying eggs, do not compete with the rising generation (MOUTHON, 1980).

The biodiversity assessment is usually based on the structure and composition of communities because biodiversity is a multidimensional concept (PURVIS & HECTOR, 2000) that reflects the biological complexity of communities (HEDDE &*al.*, 2013). By comparison of Figures 1 and 2, 3 and 4, we notice a makeable difference in the composition and distribution of the various groups pedofauna identified between healthy soil and the polluted soil of these industrial companies. The Healthy soil of EI. Shows similar rates (which do not exceed 40%) between different groups of soil fauna with the dominance of the insects due to their adaptation of the environment and surrounding natural conditions. The polluted soil shows a visible dominance of gastropods (with a rate of 70%) compared to other faunal groups. At the level of ENIEM, Healthy soil shows an almost equal distribution of various representatives of pedofauna whose rates are around 40%. We notice the dominance of Arachnids. In the polluted soil of ENIEM, we notice an apparent dominance of Gastropoda

(Over 50%) compared to other faunal groups. This abundance is the result of the high humidity of the environment due to industrial waste, the availability of limestone (DUCHAUFOUR, 1994) and the adaptation and resistance to industrial pollution by heavy metals due to their eco-physiological characteristics (GOBAT &*al*., 2010). Functional features of the species are related to the characteristics of organisms that affect their individual aptitude and govern their impacts and the responses to their environment (VIOLLE &*al*., 2007).

According BACHELIER (1978) and GOBAT &*al*., (2003), the distribution of soil fauna depends on the physicochemical nature and the depth of the soil, the changes in climatic conditions of the environment, the seasonal rhythm and diet of the relevant animal population. Soil aeration has important consequences for most biological phenomena of the soil, whether it affects the establishment and functioning of the root system or microorganism's activity (KOLLER, 2004).

Considering the season, the results reveal that the soil of ENIEM., The number of soil organisms is higher in spring compared to summer and winter in the healthy soil while this rate remains constant during the three seasons in the polluted soil. This pedofauna is affected by the seasonal effect where spring is the best period for its outbreak (CLUZEAU &*al*., 1999).

Regarding the depth in both stations, the number of individuals proportionally decreases with depth as a compact soil and low porosity may object to vertical migration of animals susceptible to temperature changes or moisture and may restrict or prohibit their existence (PESSON, 1971). This is the case of our soils that are rich in clays that does not favor migration of pedofauna by reducing the potential food and oxygen rate. We notice then that these organisms depend on their environment by the availability of some soil factors mainly moisture, the structure, the organic matter and the soil pH while an accumulation of organic matter on a much localized area on a ground is almost certain indication of pollutant deposit of any kind (PONGE, 2010). The diversity of the polluted soil compared to healthy soil can be explained by the quality of the industrial release of EI. That provides moisture and organic material for the species (as shown by soil analysis), necessary for their survival by developing adaptation and some resistance to this pollution.

Soil organisms (microflora and microfauna mesofauna and macrofauna) play key roles in the functioning of the ecosystems, (LAVELLE & SPAIN, 2001), but the pre-existing fauna in these studied soils is affected in its structure, its diversity and its specific richness due totheir change in the quality of the surrounding environment and the toxicity of heavy metals in soils and their non - biodegradability (BERKOUKI, 2011). Nevertheless, it has allowed us to detect pollution of these soils at levels lower to the acute or chronic toxicity thresholds (MARTINEZ ALDAYA & *al*., 2006; LORS &*al*., 2006; GARCIA& *al*., 2008; KOBETICOVA & *al*., 2009).

CONCULSIONS

Generally the polluted soils are characterized by impoverishment of their food web, linked to biodiversity loss with a tolerance threshold which can be defined for each group of organisms (PONGE, 2010). Therefore, prevention of the pollutant by soil animals could provide a cheap method for early detection of environmental dangers (YEARDLEY& *al*., 1996; DA LUZ & *al*., 2004; MARTINEZ ALDAYA & *al*., 2006).

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