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Diagnosis of Potential Water Contamination by Pesticides in the Sub-Basin R'Dom (Morocco)

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Abstract: This study is part of a context to develop a framework for the integrated management of water resources. It is specifically the goal of making a diagnosis of potential contamination of surface and groundwater by pesticides at the city of Meknes. To carry out this analysis, we relied on the methodological contributions of the steering committee for agricultural practices environmentally (CORPEN) [1]. As well as other scientific, [2]. As tools for data processing and analysis of results, geographic information systems (GIS) have a great contribution in the realization of this work. Indeed, maps of potential contamination of surface water and groundwater in the area of Meknes were produced. They show a spatial distribution of three classes of potential water contamination by pesticides. The results obtained in this study are a tool for decision support to the integrated management of water resources in the city of Meknes. It allows representing geographically across the city of Meknes and its surroundings, the potential for contamination of surface and groundwater.

Key words: Morocco · Meknes · Pesticides · Integrated GIS · Groundwater vulnerability decision support

INTRODUCTION

From the sixties, the modernization of agriculture and the development of chemistry led to a massive use of pesticides to protect crops and increase yields. Since then, the use of these products is questionable because several studies show widespread contamination of groundwater and surface water by at least one active substance used as a plant protection product [3]. However, the transfer of these products and agricultural fields to surface water and groundwater leads to a deterioration of the quality of water resources, harm to drinking water supply and ecosystem balance. Moreover, awareness is currently being developed on the risks that pesticides pose to the environment and to human health.

Thus problems of diffuse pollution of water by pesticides require short-term implementation of actions to reduce them. Therefore it is necessary to bring together stakeholders in agriculture and those in water management, an approach towards consultation and participation. In this sense, the present work aims to make a diagnosis of potential contamination of surface and groundwater by pesticides at the city of Meknes.

Characteristics of the Study Area: The city of Meknes is located on a plateau northwest of the Middle Atlas; it occupies an area of contact between two mountain ranges, the Prerif Western and Middle Atlas. It enjoys a Mediterranean climate mainly by the Middle Atlas and the Atlantic Ocean. Rainfall varies from 400 to 500 mm/an. It has fertile soil giving it a rich agricultural wealth is reinforced by the importance of its hydrography. Three rivers run across the city of Meknes: The river of Boufekrane, Ouislane and Bouishak, Fig. 1.

Groundwater

Aquifer: Groundwater Plio-Quaternary, is fairly well known. It manifests itself in many sources and a number of boreholes as well as a large number of wells. This aquifer is used by over a thousand wells providing both the drinking water irrigation. Groundwater flows

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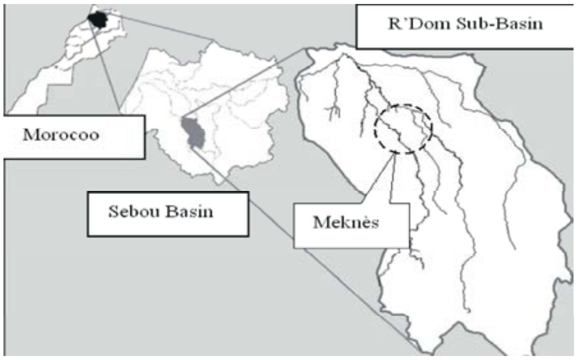

Fig. 1: Location of the study area

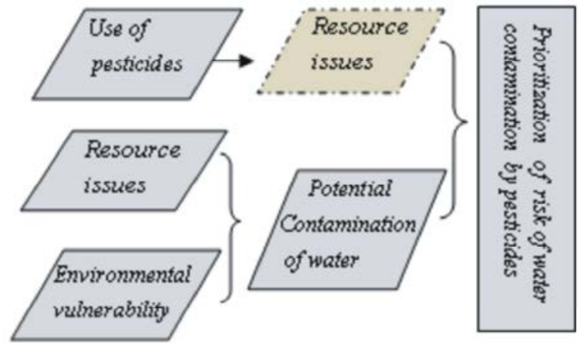

Fig. 2: CORPEN methodology

mainly in the sands, sandstones, conglomerates and limestones locally lake. Miocene marls act as waterproof wall for this aquifer [4].

Deep Aquifer: The deep aquifer is mainly fed by water seeping from the plateau through Atlas. South to the North, limestones and dolomitic limestones of the Lias is primarily an unconfined aquifer on the plateaux and borders and under the captive impervious marly formations of the Tertiary [4].

Geological Setting: With the exception of a few small areas formed by Quaternary formations. The geology of the plateau Meknes is characterized by outcrops of Pliocene and Miocene generally consist of limestone resting on sandy formations distributed locations over large areas. Sais basin has a large tertiary sedimentary structure, the seat of the Miocene deposits. This set has been in the Pliocene, the bottom of the lake basin is more or less obscured by Quaternary formations (silt, silt and clay decalcification). The bedrock of the basin is varied. It is most often made up of limestones and dolomites overlying Jurassic argillaceous red and Triassic basalts and schists and Paleozoic flysch [4].

MATERIALS AND METHODS

By adapting to local conditions and available data, the diagnosis is based on the methodology CORPEN, with some modifications in the parameters set games, the development potential maps of water contamination by pesticides in our study area. We can then describe the method used by the method CORPEN-changed.

Approach: It is a junction of three layers of geographic information namely, the use of pesticides, the vulnerability of the environment (groundwater, surface water), issues of resources (resource use), Fig. 2.

Determination of the parameters set in the games development potential water contamination:

- *The information layer "vulnerability of the resource to pollution"*

Surface Water Vulnerability: For determining the vulnerability map of pollution for surface water we used three parameters namely: the distance from the plot of drainage, topography, soil types.

Distance to the Plot: The distance from drainage was estimated taking into account the distance among the areas concerned and the hydrographic network by constructing buffer zones according to [2]. Three classes were considered with the following terminals: 50 m lower, between 50 and 200 meters and over 200 meters [2]. The figure below shows the distances to the plot of drainage. Over the application of pesticides is carried out close to the river and over the possible transfer of the active ingredients may be rapid (time possible degradation of the active ingredients in the soil is reduced). Fig. 3- (a).

Topography: The slope of the natural terrain plays a role in the acceleration of surface runoff. A steep slope increases the risk of transfer of plant protection active substances to waterways. We developed this parameter from the digital terrain model of the study area. Three slope classes were selected [2]. Figure 3 - (b).

Type of Soil: To determine this parameter we used on maps 1:50,000 soil Meknes and other layers of information on the ground in the region that have been provided by the Hydraulic Basin Agency Sebou (ABHS). Three soil classes were considered, soil permeability months, moderately permeable and highly permeable, Fig. 3 - (c).

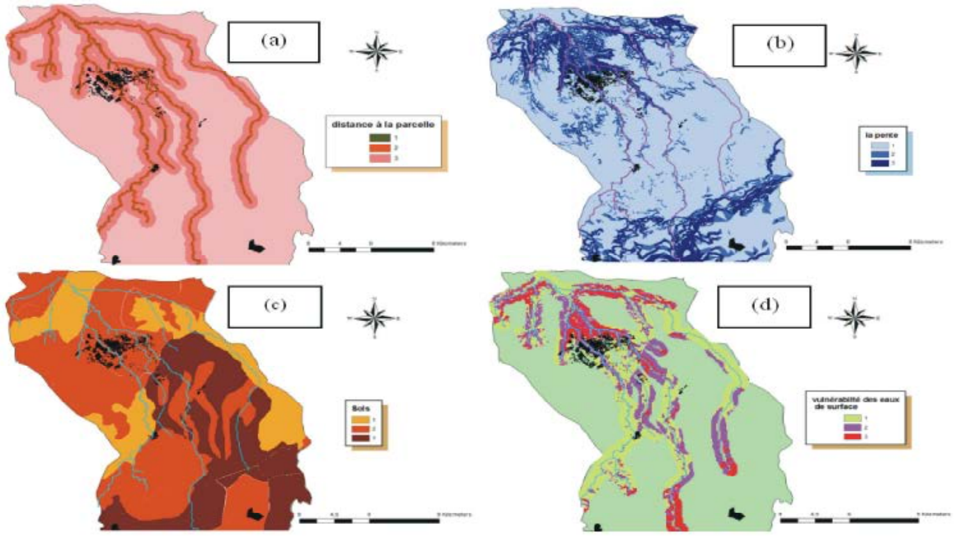

Fig 3: Surface water pollution vulnerability

The Vulnerability Map of Surface Waters: This map was obtained by the superposition of three parameters considered for the development of the vulnerability of surface waters. Three vulnerability classes were considered (Low, Medium, High), Fig. 3 - (d).

Groundwater Vulnerability: The method used for mapping of groundwater vulnerability to pollution by pesticides is the DRASTIC method. This method is a numerical rating system based on the consideration of various factors influencing the hydrogeological system and takes into account the following 7 parameters: D: Depth to groundwater, R: Recharge, A: Aquifer media, S: Soil media, T: Topography in%; I: Impact of the vadose zone and C: Conductivity. The purpose of DRASTIC is to provide a standard methodology which gives reliable results for efforts to protect groundwater [5, 6] and [7].

The final vulnerability index (Di) is the weighted sum of the seven parameters using the following formula:

$$Di = DnDp + RnRp + AnAp + SnSp + TnTp + InIp + CnCp$$

Where:

D, R, A, S, T, I, C are the parameters already mentioned;

n: rating given to each parameter;
p: weight given to each parameter.

Below how to develop the parameters used to characterize the vulnerability of groundwater.

Aquifer Lithology: the lithology of the aquifer is drawn cuts lithological and geological map of the region,[8]. Fig. 4 - (a).

Topography: From topographic maps at 1/50 000, we digitized contour lines which served afterwards to complete the digital terrain model (DTM). From this, we obtained the slope map. Coasts attributed to slope classes that are provided by the DRASTIC method. Fig. 4 - (b)

The Permeability of the Aquifer: Data on the permeability of the aquifer have been provided by the ABHS. From these data we obtained information about the layer permeability by interpolation using GIS. Fig. 4 - (c)

Depth of Water: To determine this parameter, we used data from static levels of wells that have been provided by the (AHBS). Interpolations were made from 20 boreholes that account database. The water level of the water table is met between 10 and 44 m depth. Fig.4 - (d).

Soil Texture: To determine this parameter we used on maps 1:50,000 soil Meknes and other layers of information on the ground in the region that have been provided by the ABHS. Soils encountered in the region can be divided into nine types. A score is assigned for each soil type and the method chosen, Fig. 5 - (a).

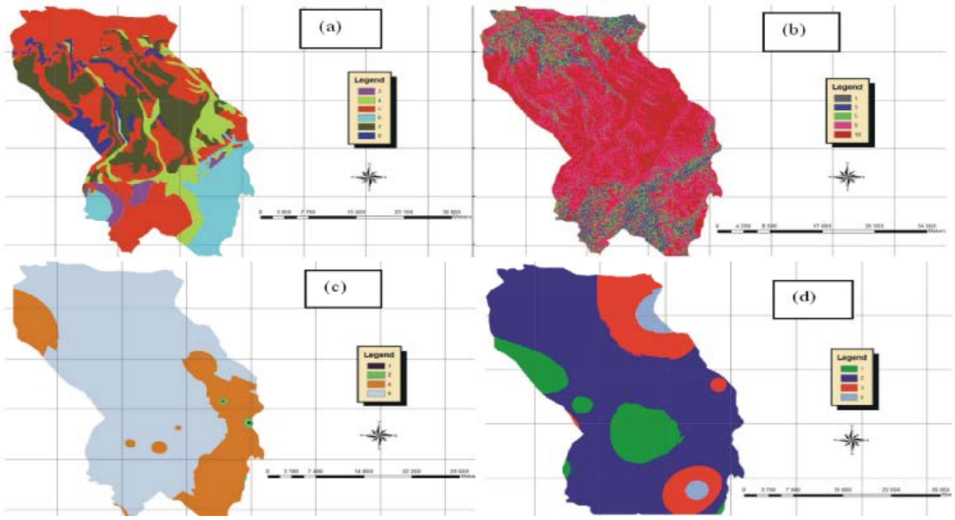

Fig. 4: DRASTIC parameters

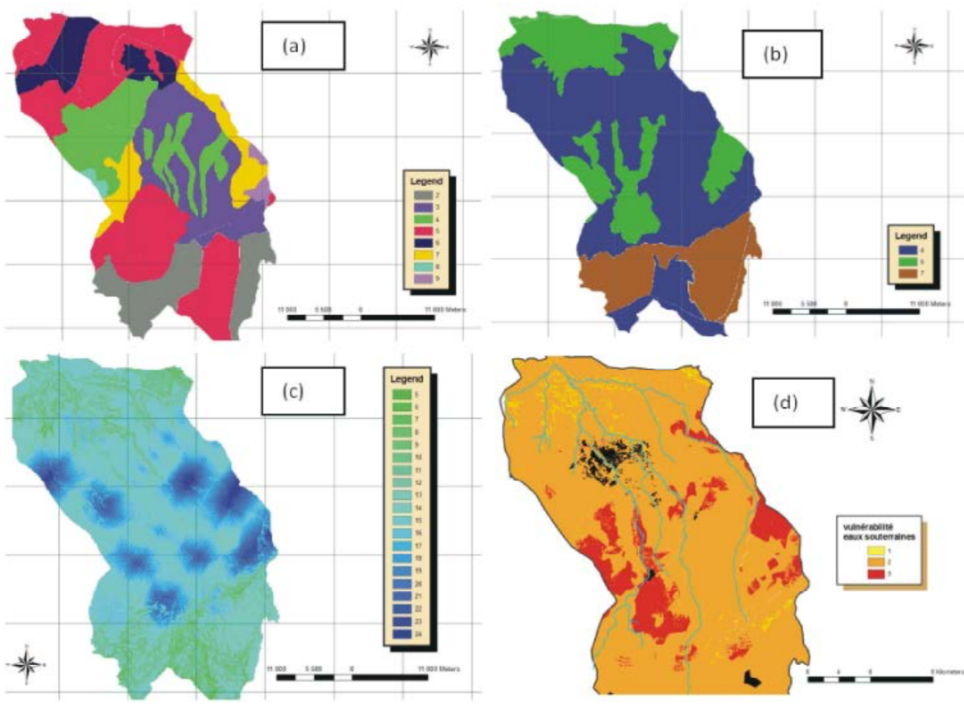

Fig. 5: Parameters and DRASTIC vulnerability map

Nature of Vadose Zone: We determined this parameter from the texture of the land area which is not saturated [8]. From the geological map of the region, a score is assigned to each type of land, more permeable to less permeable Fig.5 - (b).

Recharge: To calculate the recharge of the aquifer, we used the following method (2) as [9], RV = RF + S% + SP (2).

With: RV: Recharge value, S%: Slope RF: Rainfall factor SP: Soil Permeability.

For each of these parameters (RF,% S and SP) we assigned a rating based on the ability to increase the potential for recharge. Then, the recharge value is classified by ranges of values are given with odds determined to end contribute to the development of the vulnerability map [10]. Fig. 4 - (c).

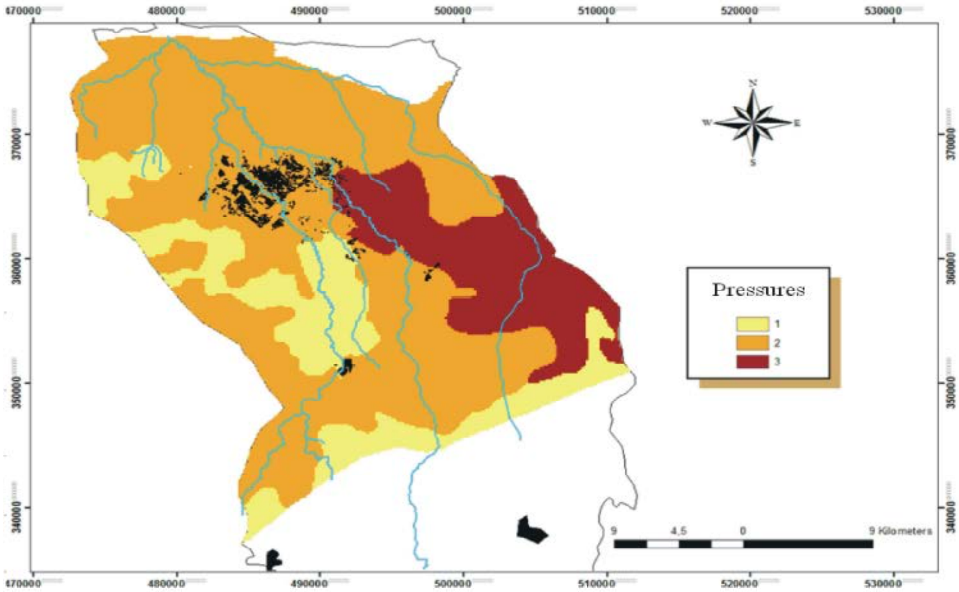

Figure 6. Map of phytosanitary pressure

Map of Groundwater Vulnerability: This map was obtained by the superposition of seven cards weighted. For the development of the vulnerability map we used three classes of vulnerability (low; Average, High), Fig. 5 - (d)

The Information Layer "Using Pesticides": It is to build a representation of the spatial distribution of the use of pesticides that is relevant in terms of risk transfer these products to the resources of surface water and groundwater.

Given that agriculture is the largest consumer of pesticides. Then to estimate the degree of plant protection practice, we used one hand survey data on the use of plant protection products in the area of Sais, conducted with farmers and distributors agricultural [11] and [12].

On the other hand, we have used data on the different cultures in the study area, [11]. The comparison of these data allowed us to establish a spatial distribution of treated areas by pesticides, Fig. 6.

The Information Layer "Resources Issues": The resources issues are many depending on the type of use, food issues, socio-economic and environmental issues. Priority levels based issues are represented in [1], in the following table.

In our case study, for surface water and groundwater, the issues on the resource have the same priority as the majority of uses of these resources belong to the class of food issues (drinking water, food, irrigation, water industrial). What makes this parameter has no influence after superposition with the two other layers of information (Vulnerability and resource use of pesticides).

RESULTS

Following this diagnosis, two cards of potential water contamination by pesticides were obtained: the potential for contamination of surface water on the one hand and groundwater other.

Contamination Potential of Surface Waters: The map of potential contamination of surface waters below, Fig. 6 shows three classes of potential contamination: low, medium and strong.

Generally, areas with the highest potential for contamination of surface waters by pesticides are areas where both the vulnerability of surface water and pest pressure are most important. It is mainly areas with vegetable crops which are subject to phytosanitary treatment to 100%, for reasons of vulnerability to many pest species.

Potential Groundwater Contamination: For a groundwater, three classes of potential groundwater contamination were considered, Fig.7. According to the results known map, areas with the greatest potential for groundwater contamination by pesticides are areas where both the vulnerability of aquifers and pest pressure are most important. Potential areas also have high recharge aquifers. Results on map show a significant area for potential class means; however areas with strong potential contamination can be a major risk to groundwater.

DISCUSSION

Several studies have been studying water contamination by pesticides [2, 13-15]. They shall adjust a number of parameters in one context to another, depending on the environmental conditions of study, available data and the rating scale. In our case study we used the method CORPEN, on which we have devoted particular changes in the parameters used in games to determine potential water contamination by pesticides.

Voltz [15] have confirmed that the outlet of the watershed frequently observed a change in the dynamics and intensity of water contamination from agricultural parcels. Thus, the residue stream measured at the outlet of a tank can be more than an order of magnitude lower than those plots. Nevertheless, the catchment outlet is the place or focus quantities of contaminants transported by trickling from large surfaces spreading. This seems to clearly map the potential contamination of surface waters, Fig. 6, which shows a high potential for contamination in the medium outlet of the watershed.

Moreover, the spatial and temporal heterogeneity of use of active ingredients within the watershed produces a dilution of contamination depending on the nature of the active ingredients. Indeed, the flow paths and environments through which contaminated water between plots treated with plant protection products and the outlet of the watershed are often multiple. This can result, variations in the transmission of contamination to the water. These phenomena vary greatly depending on the nature of the watershed and climatic conditions. The results of this work are to support decision support, especially for farmers and resource managers, on the other hand, taking into account technical proposals for the use of less hazardous material to the environment and Health and acceptance of standards for use of products in terms of dose for each molecule.

CONCLUSION

The diagnosis of this contamination of surface water and groundwater by pesticides is a tool for decision support, especially to managers and agricultural professionals. It allows to represent geographically across the city of Meknes and its surroundings, the potential for contamination of surface and groundwater. He used to determine priority areas for the implementation of actions aimed at maintaining water quality, identify areas where further improvement phytosanitary practices should be a priority and is also a means of reflection for other future studies.

In addition to the results presented in this work, having served in the establishment of agricultural pollution pressure on the quality of water resources, agricultural officials in the region of Meknes may propose technical routes for the choice of molecules and doses, with less risk of transfer of pesticides to water resources. End cards Contamination of water produced will be updated in the medium or long term, in order to observe changes over time in the risk of water contamination by pesticides in the city of Meknes.

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