Geoindicators applied to the risk of groundwater contamination due to urban expansion and externalities in Mar del Plata, Argentina

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Abstract: In Mar del Plata, Argentina, the urban expansion in low areas lacking services, as well as the poor development of final disposal sites for solid urban wastes and the surface drainage alteration constitute a scenario affecting groundwater quality mainly in periurban areas. Prediction, monitoring, prevention and mitigation constitute a sequence of decisive steps to implement a programme based on geoindicators to risk of groundwater contamination.

Key words: geoindicators, risk, groundwater contamination, Mar del Plata, Argentina

Introduction

Mar del Plata, located on the Atlantic coast, is the main tourist center in the country and has a population of 600,000 inhabitants increasing threefold during the summer (Fig. 1). Groundwater quality is a serious concern considering that water for urban, agricultural and industrial use is exclusively supplied by groundwater resources. The periurban area becomes the ideal site for the development of clandestine landfills, undesirable industries, precarious shantytowns in areas under flood risk (del Rio, 2002).

The main geoenvironmental problems detected are: saline intrusion, pollution of groundwater, inadequate waste management, recurrent floods in the urban and periurban areas and uncontrolled urban expansion. The main sources of pollution were studied by Massone et al. (1998) and a programme for risk management in the contamination of groundwater resulting from leachate in landfills at Mar del Plata was proposed by Bocanegra et al. (2001).

A sequence of steps designed to predict, monitor, prevent and mitigate groundwater contamination as a programme to risk management is herein suggested.

Urban expansion and externalities in Mar del Plata

The urban expansion rate was of about 10,000 inhabitant/year in the last decades. This contributed to an unavoidable process of conurbation in suburban areas, facing conflicts and environmental hazards due to deficient or inexistent services. People established in neighbourhoods of medium density often built on flooding areas. The strong storms that

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affected Mar del Plata during the last 10 years, produced at least 2,000 evacuated people and represented human and economic losses estimated at around 5 million dollars.
Official landfills, which have mainly been used as dumping sites, receive 700 tons a day during the winter; and more than 1,200 tons during the summer. Over the last 25 years, they have been built in recharge areas on surface watersheds. A contaminated plume coming from the oldest landfill has been identified in groundwater (MASSONE ET AL., 1998).

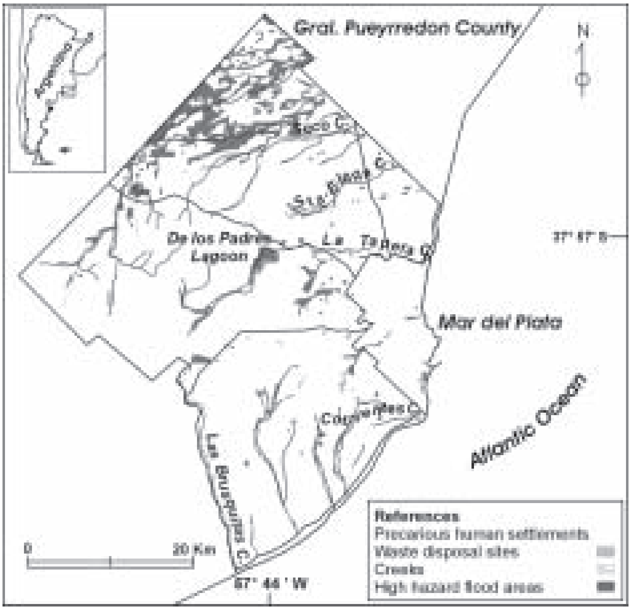

Figure 1. Map of Gral. Pueyrredon County

METHODOLOGICAL FRAMEWORK

Among the many geological risks, the aquifer pollution is a clear example of an induced risk. The risk evaluation and the risk management may be developed into four often overlapping and feed backing stages: prediction, prevention, monitoring and mitigation.
The geoindicators are a useful tool in order to define the temporo-spatial evolution of environmental processes and integrate the four stages of intervention mentioned above. They are addressed to decision-makers and designed to assess:
1) environmental PRESSURE caused by human activity
2) environmental conditions or STATE
3) anthropic RESPONSE to correct undesirable situations.
The procedure proposed is based on the ELANEM (Euro-Latin American Network on Environmental Assessment and Management) project (CENDRERO, 2001), established for the calculation of indices:
a) Normalised indicators using a 0-1 scale, as continuous values or divided into categories.
b) Indices of pressure, state and response, which can be integrated in an average calculus of environmental quality.

Prediction and monitoring

Prediction bases on a conceptual or numeric diagnosis of the current situation and allows determining the pressure exerted in a given time on the analysed resource, and the response the system shall have. Monitoring determinates, in a given time, the significant parameters of the analysed environment or resource, so as to define their quality conditions. To predict the future behaviour of the system, the measure of parameters assessing the pressure exerted on it shall be oriented towards: 1)Availability of water resources (absolute, m^3/person), 2) Data on average annual stream discharge (m^3/year), 3) Annual aquifer recharge (mm/year), 4) Total population lacking sanitary services (inhabitants/ km^2), 5) Area affected by industrial and urban waste disposal sites (absolute), 6) Annual volume of urban waste produced (absolute), 7) Untreated waste (absolute), 8) Polluting industries (absolute), 9) Farms (cattle) under intensive exploitation (km^2), 10) Annual consumption of fertilisers and pesticides (absolute, km^2).

In order to monitor groundwater quality, the significant parameters able to be measured are as follows: 1) Unsaturated thickness (m), 2) Actual use of the resource (absolute, m^3/person), 3) Area affected by industrial and urban waste disposal sites (absolute), 4) Nitrate pollution in water courses and groundwater (ppm in selected points), 5) Bacteriological pollution (nmp of faecal coliform colonies), 6) Heavy metals in water and sediment (ppm in selected points), 7) Persons affected by hydric diseases treated in hospitals (Number of affected persons).

Prevention and mitigation

These terms are defined as the group of policies, measures, and actions planned and duly executed, oriented towards granting a RESPONSE and avoiding the contamination risk.

Prevention articulates with mitigation, the latter defined as the group of actions and measures taken to change, attenuate, or eliminate alteration or degradation processes or the contamination produced in the system.

The efficacy of these actions is measured through the following environmental response indicators: 1) Annual public expenditure on consumption reduction ($/year, person), 2) Public expenditure on water supply, treatment ($/year, person), 3) Enforcement of anti-pollution regulations. (Absolute number), 4) Extent of organic farming. (absolute, km^2), 5) Public expenditure on animal waste and agrochemical pollution reduction. (Absolute), 6) Annual expenditure on urban (and industrial) waste disposal ($/year), 7) Administrative and jurisdictional organisation (department budget, staffing).

Conclusions and Discussion

The proposal of a diagnosis, the evaluation of geoenvironmental conditions, the solution to conflicts and risk assessment must be the result of a conscious inter-multi-disciplinary work, in which the people affected might participate. From a methodological viewpoint, the challenge lies in adopting operative strategies allowing to interpret the evolution of the groundwater systems, according to different temporal and spatial scales; as well as to allow a quick, efficient and efficacious systematic update of the data available. Therefore, the geoindicator method herein suggested is a potentially valuable tool for groundwater resources preservation.

On the other hand, the following preventive and mitigating actions of immediate application would be recommended:

1. Avoid high density settlements in zones lacking sewage services;
2. Avoid urban settlements on rural and productive areas;
3. Avoid conurbation tendencies specially in areas of flood risk;
4. Execute an effective control on private water supply wells (pursuant to OSSE –Sewage and Running Waste Systems Provider- regulations);
5. Develop active policies to occupy the flood plains with equipment of low susceptibility, such as football and basketball pitches, picnic sites, parks, etc;
6. Localise final disposal sites in those environmental areas of greater aptitude;
7. Carry out final waste disposal –in case of landfills- pursuant to the safe, reliable and permanent conditions described by the sanitary engineering principles; and forbid informal recyclers accesses to the site;
8. Establish the unified authority in charge of groundwater protection and control of final waste disposal.

FINAL COMMENT

Poverty and degradation of water quality and quantity are the main environmental problems in Latin America. The lack of information, of updated and accurate data, and furthermore the atomisation in multiple institutions of the existing ones, constitute a problem extremely difficult to solve, in order to implement, on a rational basis, actions or constructive policies for the groundwater management. This, requires research and technical co-operation agreements between international and national, provincial, municipal or private entities in order to build data banks to diagnose and improve the solutions to the problems.

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