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Identifying suitable sanitary landfill locations in the state of Morelos, México, using a Geographic Information System

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ABSTRACT

GIS is a powerful tool that may help to better manage natural resources. In this paper, we present a GIS model developed for the state of Morelos as an aid to determine whether a potential site, Loma de Mejia, met the Mexican Federal Guidelines. The Mexican Government has established federal guidelines for sanitary landfill site selection (NOM-083-SERMARNAT-2003). These guidelines were translated into a water-based Geographic Information System and applied to the state of Morelos, Mexico. For these examples, we used the SIGAM® (Sistema de Información Geográfico del Agua en México; a water-based GIS for Mexico) which has at least 60 layers from the National Water Commission (CONAGUA), the national mapping agency (INEGI; Instituto Nacional de Estadística, Geografía e Informática), NASA, and academic institutions. Results show that a GIS is a powerful tool that may allow federal, state and municipal policy makers to conduct an initial regional site reconnaissance rapidly. Once potential sites are selected, further characterization must be carried out in order to determine if proposed locations are suitable or not for a sanitary landfill. Based on the SIGAM© software, the Loma de Mejia would not comply with the Mexican Federal Guidelines.

1. Introduction

In this paper we first give a brief description on the hydrogeology of Mexico, the importance of ground water as a strategic resource, and how ground water is affected by contamination generated from sanitary landfills followed by a case study using the SIGAM® (Sistema de Información Geográfica del Agua en México; Water-based Geographic Information System for Mexico) developed by Marín et al. (2011). The SIGAM® was used to identify suitable areas to potentially locate a sanitary landfill in the state of Morelos according to the criteria of the Mexican regulation.

1.1. Hydrogeology of Mexico

Mexico has approximately 2 million square kilometers and a population on the order of 100 million inhabitants. This is in contrast with a population of 25 million in 1950. The geographical location of the population and principal industrial sites are inversely related to water availability. The climate in the northern two thirds of Mexico is arid to semi-arid and this is where the largest cities are found as well as most of the population, industrial and agricultural activity. However, this area has less than one third of the total water resources of the country (Fig. 1). Thus, ground water plays an essential role in the Mexican economy, since in the northern two-thirds, ground water is the main, and often, the only source of water.

Nationally, approximately one third of the total water use (agricultural, drinking water supplies, and industrial) comes from the water found beneath the ground surface. Ground water provides more than 70% of the drinking water supplies nationally. Approximately 75 million people (55 million live in the main cities, such as Mexico City, and 20 million are rural inhabitants) depend on ground water as their only source of water. Ground water is used to irrigate approximately 2 million hectares (about one third of the total agricultural land). Ground water is particularly important for agricultural products that are exported because it is not subject to temporal patterns (such as droughts), it is readily available, and it is cheap.

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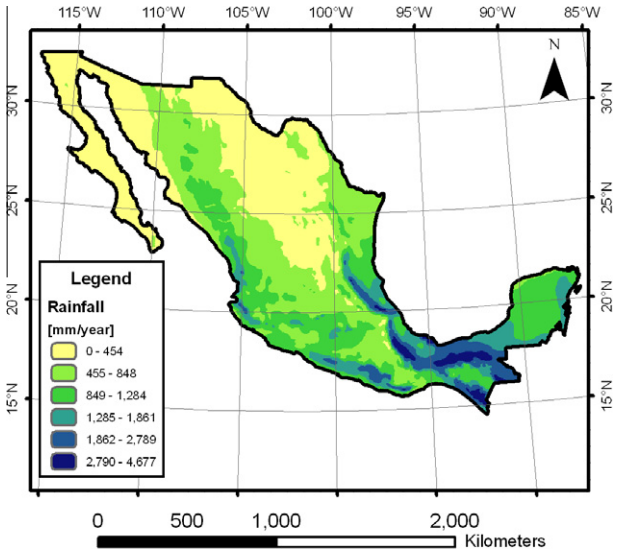

Fig. 1. Precipitation map for Mexico.

The national ground water balance is positive since extractions are about 70% of natural recharge. However, due to the spatial and temporal distribution of rainfall, this positive balance can be misleading. Southeastern Mexico, which has the greatest volume of available water, is also the least developed both in terms of agriculture and industry. The highest demands for ground water occur in the arid and semi-arid areas of central, northern and northwestern Mexico, where the ground water is being mined, and as a result, over 100 aquifers are currently being overexploited in this area (Marin, 2002).

Aboites et al. (2008) have suggested that for the water sector "official information" (i.e. information that is provided by the federal government agencies) is confusing, not published in a timely manner, is imprecise and not collected in a systematic fashion, not readily accessible for the population in general, and is hardly used by government agencies. One way to overcome this deficiency in the water and solid waste sector is through the use of a water-based GIS. Marín et al. (in preparation) have developed a water-based GIS called the SIGAM® (Sistema de Información Geográfico del Agua en México) (Marín et al., 2011). The SIGAM® is a GIS that integrates information from diverse sources such as federal agencies in Mexico, national and international academic institutions. It has different thematic layers such as DEM (Digital Elevation Models), hydrology, hydrogeology, climate, and geology.

1.2. Solid waste in Mexico

In addition to the water supply issue, water quality has also developed into a major problem due to the tremendous increase in population and waste generation resulting from human activities.

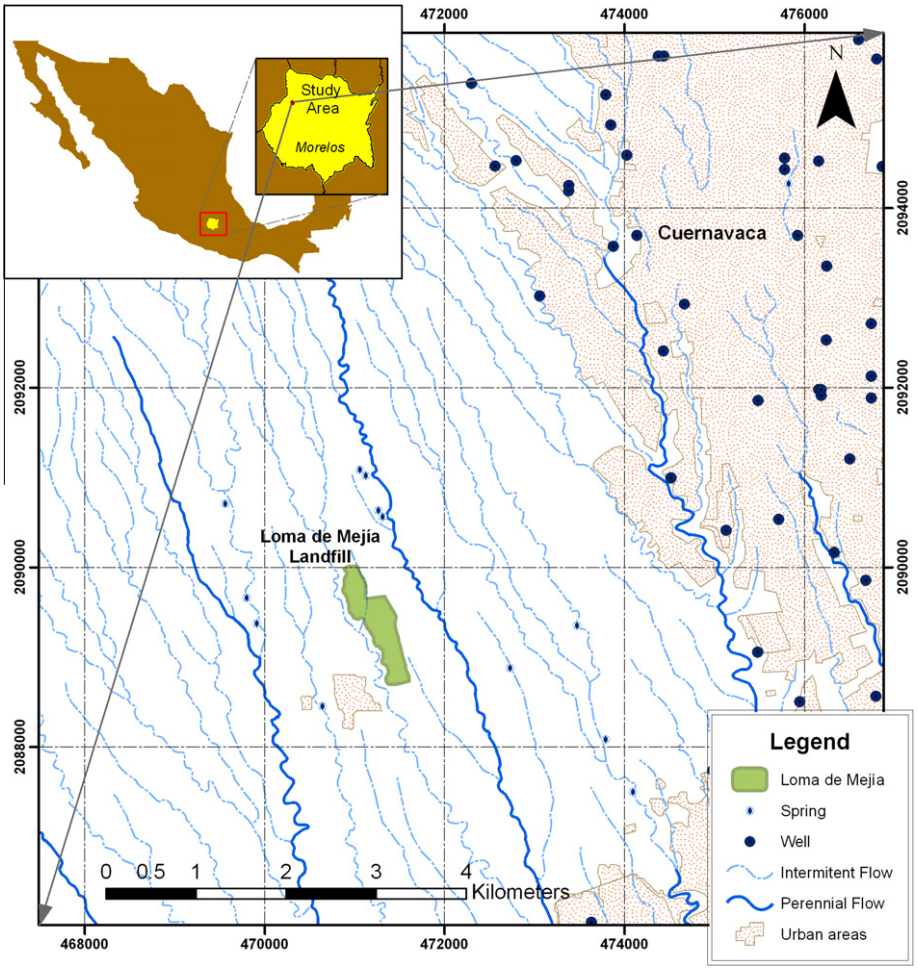

Fig. 2. Location of Loma de Mejía.