*2012 International Conference on Environmental Science and Technology*
*IPCBEE vol.30 (2012) © (2012) IACSIT Press, Singapore*

# "Environmental Assessment and Sustainable Development of Valsequillo in Puebla, Mexico"

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**Abstract.** The results presented in this article were generated from the southern Puebla City, Mexico in Valsequillo Dam which was studied for environmental assessment during 2009. We are proposing an environmental strategy plan for recovery and subsequent improvement for sustainable development. The environmental problems in the study area can be resolved through the following environmental strategies for achieving a sustainable development in the area: 1) by reducing the load of pollutants discharged by urban industries; 2) the water quality in Valsequillo Dam, can be improved and it can be utilized in different applications; 3) wastewater from communities less than 1,000 inhabitants can be recycled for future use; 4) a plan for restoration and conservation of soil can be made so that it can be used for recreational activities; 5) the conservation areas can be protected (ANP and volcano) 6) a program to promote recovery and recycling of materials generated from the municipal solid waste can be done; 7) the macroplantas sludge from wastewater treatment of Alseseca south and south Atoyac rivers can be removed.

**Keywords:** environmental assessment, enviromental strategy, Valsequillo, Puebla, México.

## 1. Introduction

As part of the *"Partial Urban Development Program Sustainable Valsequillo and its influence zone"* was done by CIIEMAD – IPN in the period 2009 – 2010. Finally, an environmental assessment study was done in the region to determine the environmental problems and we have proposed a number of strategies for protecting the biotic wealth conservation, restoration and protection to have an sustainable development in Valsequillo.

The Valsequillo region and its zone of influence, is the Manuel Ávila Camacho dam or Valsequillo, built in 1946 is to provide water for irrigation to the villages that are situated in the Valleys of Irrigation District 030 and in the irrigational zone Atlixco - Izúcar de Matamoros. Valsequillo receives runoff from 22 cities of Puebla city and 48 villages of Tlaxcala municipalities. These materials include organic and industrial discharges that have made the work of sanitation in Atoyac River Basin a little bit more harder (Bonilla, et. al. 2008). The Valsequillo dam is a barrier that separates to urban localities located in the north of the rural areas than to the south of Puebla City. In the southern region, the Sierra del Tentzon municipality is considered as a natural area characterized as biologically and culturally very rich in their localities (Díaz, et. al. 2008). The environmental strategy seeks to link the development of Valsequillo Dam and its area of influence to a dynamic process that will increase the environmental capacity and quality of the territory by generating a balance between urban, rural and environmental systems.

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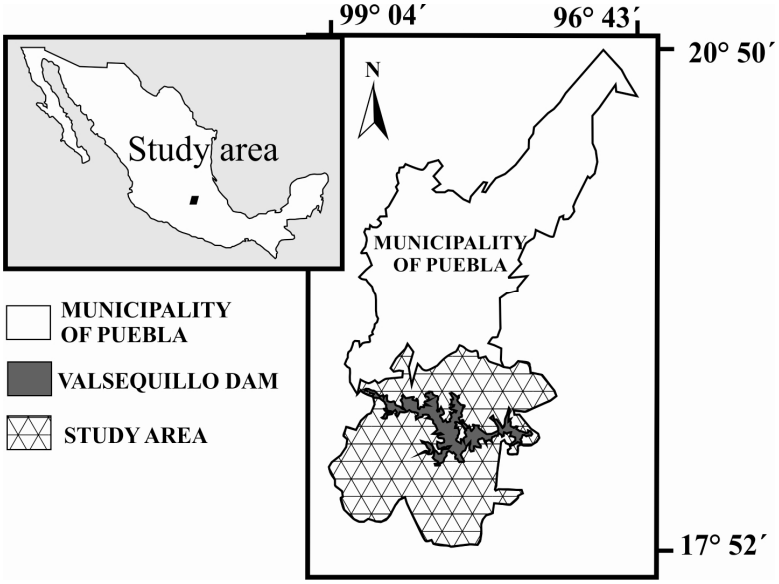
## 2. Methods

To understand the environmental problems in Valsequillo region and its area of influence, we made a detailed review which was mainly focused on factors involving: climate, geology, soil erosion, hydrology, hydrogeology, major ecological regions and deforestation. In addition, in order to establish the degree of water pollution we collected nearly 42 samples and analyze them for physicochemical parameters and toxic dissolved metals.

### 2.1. Study Area Description

The study area is located south of Puebla City and it covers a surface area of 236.13 km$^2$. The Valsequillo Dam covers nearly 11.99% (28.32 km²) of the total surface area in the study area (Domínguez, et. al., 2004). The average height of Puebla municipality is 2,125 m above MSL and it is geographically located in the Volcanic Transversal Axe. The region is the most important volcanos in the country such as Pico de Orizaba, Popocatépetl, Iztaccihuatl, Malinche, Sierra Negra (Tliltépetl) y Cofre de Perote (Figure 1).




Source: CIIEMAD - IPN.

Fig. 1: Delimitation of the study area

The climatic conditions in this region are temperate-humid and semi-hot, sub-humid. The rainfall varies from to 740 to 1200 mm and the temperature ranges from 5 to 18 °C. In the edge of La Malinche volcano the temperature fluctuates between 5 to 15 $^o$C and in the central part of municipality in the southern limit, the temperature ranges from 16 to 18 $^o$C. The minimum temperature observed at the top of volcano La Malinche is 5°C and in the southern part it usually is around 18°C. With reference to the wind condition, 85% of wind direction is from the NNE direction. The dominant wind direction is NNE and SSW, with a mean wind speed of 1.6 m/s (Cedeño-Valdés, et. al. 2008).

The Geology in the study area is constituted by rocks of the quaternary and tertiary periods. In addition, sedimentary rocks of volcanic origin are also seen in the urban central part and carbonated rocks are seen as intrusions in the south and the north of the study area (Figure 1). The contrasting characteristic between soils from east and west is that it is rich in organic matter content, and the soil layers are eroded without horizon A both in the north and south. The study area is also dominated by the sheet, gully and islets, which are erosional features. The erosional features was determined by analyzing the loss of soil horizons A, B and C are absent or mild or moderate or severe and in some places it is very severe.

The hydrological basins of the rivers Atoyac (before and after its confluence with the basin San Francisco River) and Alseseca, is the most important contributors to the reservoir Manuel Ávila Camacho (Valsequillo) Dam. According to recently published information of Puebla City, the Tlaxcala aquifer is been over exploited and it is identified by the decreasing level since 1973 with a rate from 2-3 m/year. The accumulating loss is calculated at 188 Mm$^3$ at a rate of 12 Mm$^3$/year (Saldaña, et. al. 2008).

Table 1: Characteristics of the soil from the study area

| Soil subunit | Location | Characterictis |
|---|---|---|
| Haplic Feozem | East and West of the Valsequillo dam | Black-colored soil, rich in organic matter, clayey. |
| Calcaric Regosol | West of the Valsequillo dam | Sandy soil texture, poor in organic matter, shallow (0-50 cm deep), reacts to HCl, has a horizon A ochric. |
| Calcic Cambisol | East of the Valsequillo dam | It presents a horizon in process of change, has a horizon B with calcium carbonate accumulation. |
| Rendzina | South and southwest of the Valsequillo dam | It presents a horizon A, black-colored soil, on lies as Limestone material, clay with a depth less than 50cm. |
| Vertisol Pellic | North of the Valsequillo dam | Soil depth (+100cm), more than 35% clay, black-colored, rich in organic matter, many fine pores, presents facets of friction. |

Source: CIIEMAD, 2010.

The most significant major ecological regions of the study area is Sierra Tentzon, and it is surrounded region (Valsequillo). In the industrial sector, more than half of the Puebla State territory is used for manufacturing, domestic and commercial uses. However in the period between 1970 and 1990, most of the municipalities in the state had a significant loss of the forest area. Overall, there are 19 municipalities with high and very high population levels, where the forest areas have suffered a total loss.

## 2.2. Water sampling and analysis

Overall, 37 water samples were collected of which, 11 were from rivers and 26 in the Valsequillo Dam (11 surface and 15 to 37 at middle distance and background). Physicochemical parameters such as temperature, pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (OD); and metals elements aluminum (Al), arsenic (As), barium (Ba), cadmium (Cd), copper (Cu), total chromium (Cr), iron (Fe), manganese (Mn), lead (Pb), zinc (Zn), cobalt (Co), strontium (Sr), potassium (K), magnesium (Mg), nickel (Ni) and vanadium (V).

# 3. Results and Discussion

## 3.1. Physicochemical parameters and metals in water

The average values of physiochemical parameters from Rivers Alseseca and Atoyac and Valsequillo Dam is presented in Table 2. Likewise, the average results of metals from the rivers and the dam sites are presented in Table 3.

Table 2: Average results of the physiochemical parameters for the rivers and the Dam.

| Mean | T [°C] | pH | OD [mg.L$^{-1}$] | BOD [mg.L$^{-1}$] | COD [mg.L$^{-1}$] |
|---|---|---|---|---|---|
| Alseseca river | 21.0 | 7.85 | 1.50 | 247 | 542 |
| Atoyac river | 20.2 | 6.95 | 0.47 | 59 | 238 |
| Valsequillo dam | 19.4 | 2.5 | 2.5 | 11.6 | 23 |

According to the results, they indicate that the water quality in the Rivers Atoyac and Alseseca and the Valsequillo dam did not fulfill with certain quality standards. This is also due to the Rivers Zahuapan, Atoyac and Alseseca, which are the main contributors of pollutants entering into the Valsequillo dam (Bonilla, et. al 2008b). This rivers criss-crosses the industrial parks and industries which are principally engaged in activities related to textile, chemical, construction, automotive, petrochemical and electromechanical industries.

The rivers are also recipients of transported agents from the industrial and municipal collectors in the region. The physical, chemical and biological results in our study indicate that the parameters were high for chemical and biochemical oxygen demand (COD and BOD) and for metals. Figure 2 clearly indicates that the behavior of metals with aluminum.

Table 3: Average results of metals in mg.l-1for the rivers and the Dam

| Mean | T [°C] | pH | OD [mg.L$^{-1}$] | BOD [mg.L$^{-1}$] | COD [mg.L$^{-1}$] |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Alseseca river | 21.0 | 7.85 | 1.50 | 247 | 542 |
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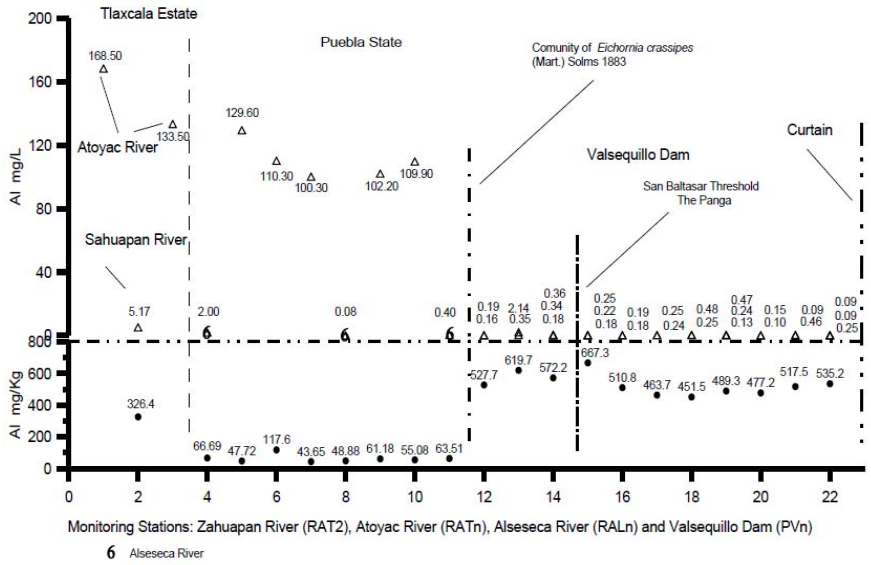



Source: CIIEMAD – IPN, 2010.

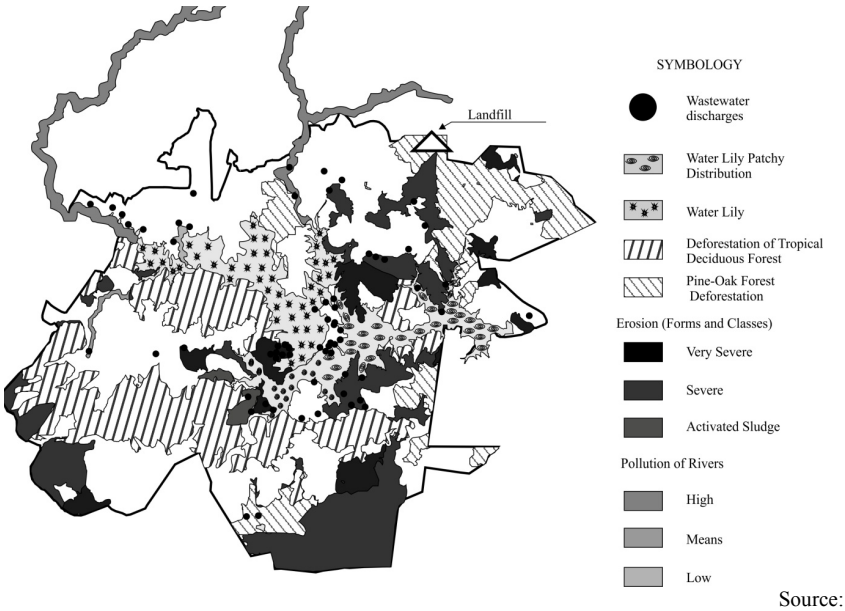
Fig. 2: Concentration pattern of Al in water from rivers and dam site in the study area.

The results also indicate that River Alseseca is the main contributor in the load of chemical and biochemical oxygen demand. Likewise, for dissolvable metals River Atoyac is the main contributor of Al, Ba, Cd, Co, Fe, Mn, Ni, Pb, V and Zn. However, potassium is seen as the main contributor from River Alseseca.

## 3.2. Environmental problematic

The environmental assessment in the study area indicates that the contamination problems is mainly due to the discharges of untreated wastewater, generation of hyacinths in the reservoir of the dam, deforestation of tropical deciduous forest, deforestation of pine and oak, severe erosion, activated sludge, and pollution of the rivers.

The environmental problems in the study area can be solved through the following environmental strategies and a sustainable development in the area can be achieved by: 1) reducing the load of pollutants discharged by industries; 2) by improving the quality of water in the Valsequillo Dam and by utilizing it in different applications as in and out of the rivers; 3) the wastewater from communities less than 1,000 habitants can be reused; 4) by developing a soil erosion plan for restoration and conservation and subsequently for its use as recreational area; 5) by conservation of areas (mountains of Tenzon and volcano) to establish national and international green programs, which is a resource exploitation for carbon fixing program; 5) by introducing municipal solid waste program to promote recovery and recycling of materials generated in the polygon; 6) by establishing a comprehensive treatment program that can be done for macro plants sludge from wastewater treatment from Rivers Alseseca south and south Atoyacfor effective management plan.




Source: CIIEMAD – IPN, 2010.

Fig. 3: shows the regionalization of mayor environmental problems identified at the site of action.

## 4. Conclusions

The Valsequillo Dam and its associated locations have a social, economic and are environmentally heterogeneous in composition. The presence of urban elements, industrial and rural areas indicates a complex problem. The topography and the formation of the rivers that criss-crosses the city of Puebla and it subsequently drains into the dam. In contrast, the rural areas coexist with the southern city of Puebla, resulting in complexity for finalizing a strategic solution with integrated and sustainable character. The possible elements of this environmental strategy are: 1) Reducing the load of pollutants discharged; 2) Improving the quality Water of Valsequillo Dam and its use of different applications; 3) Reusing the wastewater from communities less than 1,000 habitants; 3) Restoration and conservation of soils; 4) Conservation Programs for various regions; 5) Municipal solid waste program; and 6) Introduction of macro and micro treatment plants.

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