Fate of emerging contaminants during infiltration of untreated wastewater: The world´s largest example in The Mezquital Valley, Mexico

Luis E. Lesser, Ph.D. *, Lesser y Asociados, S.A. de C.V., Queretaro, Qro, Mexico . Civil Engineering, TEC de Monterrey, Queretaro, Qro, Mexico*

Aldo I. Ramirez, Ph.D. *, Centro del Agua para America Latina y el Caribe, TEC de Monterrey, Monterrey, NL, Mexico*

ABSTRACT

The Mezquital Valley is the world's oldest and largest example of usage of untreated wastewater for agricultural irrigation. North of Mexico City, the Mezquital Valley receives, since the 1950s, untreated wastewater through three different main sewage drains from Mexico City (an open canal and two deep sewage systems, with a third deep sewage close to completion). Currently, more than 45 ha are irrigated with approximately 50 m^3/s of this untreated wastewater in the Mezquital Valley. Eighty one percent of the main canals, and 52% of secondary canals are unlined, with water infiltrating directly into the shallow aquifer. Because of the high artificial recharge in the area, groundwater is extracted for human consumption from the deeper aquifers.

This study analyzed 218 organic microcontaminants in wastewater canals, springs and groundwater from the Mezquital Valley. Five volatile organic compounds (VOCs) and 9 semi-volatile organic compounds (SVOCs) were detected in the wastewater used for irrigation. Only 2 SVOCs were detected in all the wastewater canals and groundwater sources, whereas no VOCs were detected in groundwater and springs. Of the 118 pharmaceutically active compounds (PhACs) and 7 reproductive hormones measured, 65 PhACs and 3 hormones were detected in the wastewater.

In groundwater sources, 23 PhACs were detected. Most of these compounds have low concentrations compared to those detected in canals. There were only few detections and at lower concentrations in the deeper aquifers. These results suggest that the subsurface acts as a filter, adsorbing and degrading most of the organic pollutant content in the infiltrated wastewater. A new wastewater treatment plant (PTAR Atotonilco) is being built to treat the wastewater prior to its release to the Mezquital Valley. The geochemical changes that this cleaner water will produce when infiltrated into the aquifer have not been assed yet.

INTRODUCTION

The Mezquital Valley is the world's oldest and largest example of usage of untreated wastewater for agricultural irrigation. North of Mexico City (Fig. 1), the Mezquital Valley receives, since the 1950s, untreated wastewater through three different main sewage drains from Mexico City. The main sewage systems include an open canal (Gran Canal) and two deep sewage systems (Tunel Emisor Poniente and Tunel Emisor Norte), with a third deep sewage close to completion (Tunel Emisor Oriente or TEO).

Currently, more than 45 ha are irrigated with approximately 50 m3/s of this untreated wastewater in the Mezquital Valley. Eighty one percent of the main canals and 52% of secondary canals are unlined, with water infiltrating directly into the shallow aquifer (Fig. 2). Because of the high artificial recharge in the area, springs have develop in the area, being the most notably Cerro Colorado spring (60 in Figure 1) and Tezontepec (12 in Figure 1) with flow discharges of 400 and 200 litres per second respectively. These springs have been shown to have detectable levels of different contaminants (IMTA, 2010).

Groundwater is also withdrawn through pumping wells, although pumping wells for human consumption withdraw water from the deeper aquifers (Fig. 3). A third route for aquifer discharge occurs through artificial drains, which have been created in areas where the shallow groundwater levels cause problems to roots of irrigated crops.

OBJECTIVE

Previous studies have shown spread out contamination throughout the valley, however no clear distinction has been made between water samples coming from shallow vs. deeper aquifers (Downs, et al., 2000; Friedel et al., 2000; Jimenez and Chavez, 2004; Jimenez, et al., 2008).

The objective of this study was to determine the ubiquity of volatile (VOCs) and semi-volatile organic compounds (SVOCs), in addition to emerging contaminants (pharmaceutically active compounds or PhACs and reproductive hormones) in the from the wastewater used as irrigation in the Mezquital Valley, and determine the possibility of finding these compounds in drinking water wells in the area.

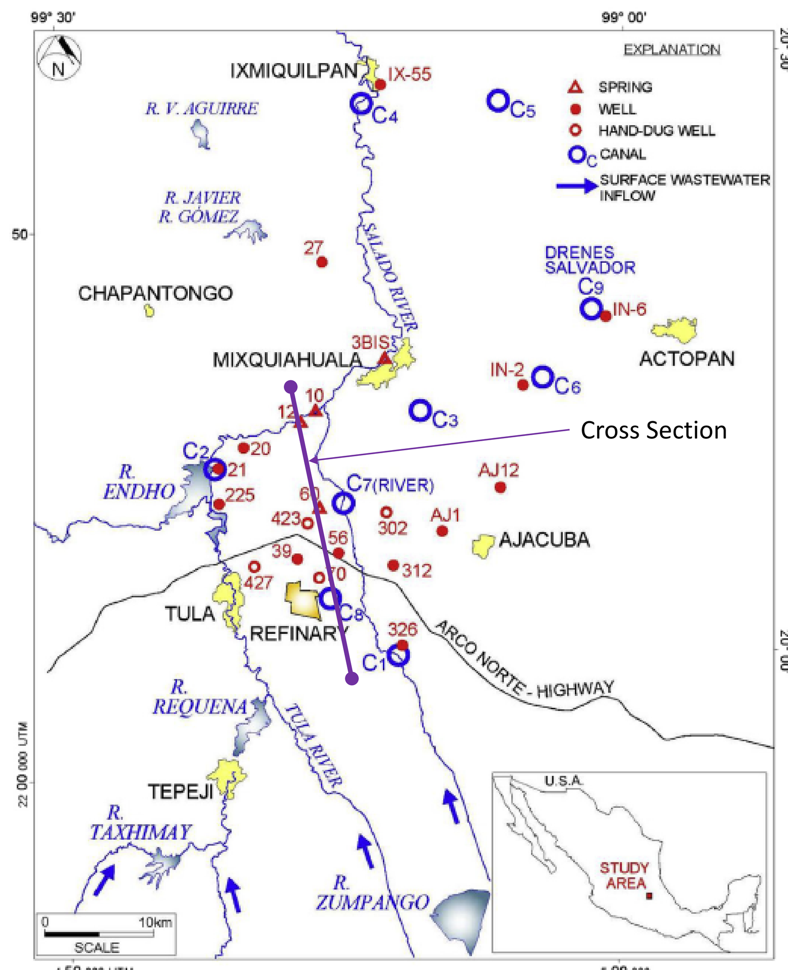

Figure 1. Map of the study area showing the inflow of surface wastewater into the Mezquital Valley and the sampling locations of wells, springs and the main wastewater canals used for irrigation

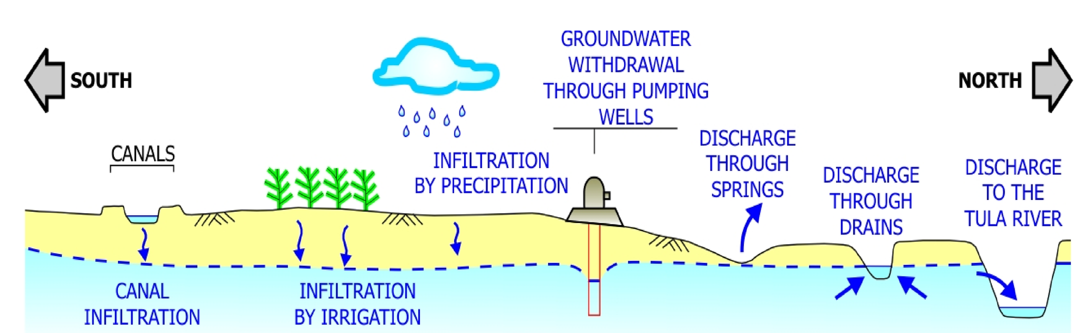

Figure 2. Conceptual Mezquital Valley Aquifer Performance. Infiltration occurs from irrigation and unlined channels. The origin of this water is Mexico´s City sewage. Water outflow occurs through pumping wells withdrawal, springs and artificial drains

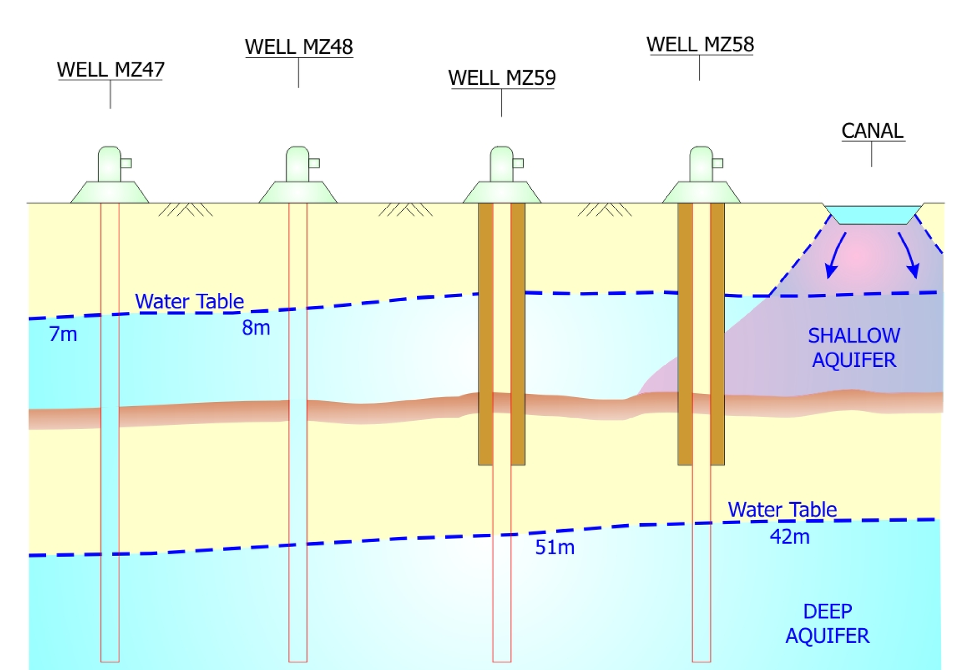

Figure 3. Shallow and deep aquifers in the Mezquital Valley. The shallow aquifer is the most clearly contaminated aquifer, while seldom pollution has been detected in the deep aquifer.

METHODS

This study analyzed 218 organic microcontaminants in 9 samples from wastewater canals (Fig. 4), 4 samples from springs (Fig. 5) and 17 samples from groundwater wells from the Mezquital Valley. This study was part of a larger project which included visiting and measuring water levels and pumping rates at 460 wells and springs, 50 pump tests, a geophysical study and a groundwater flow model.

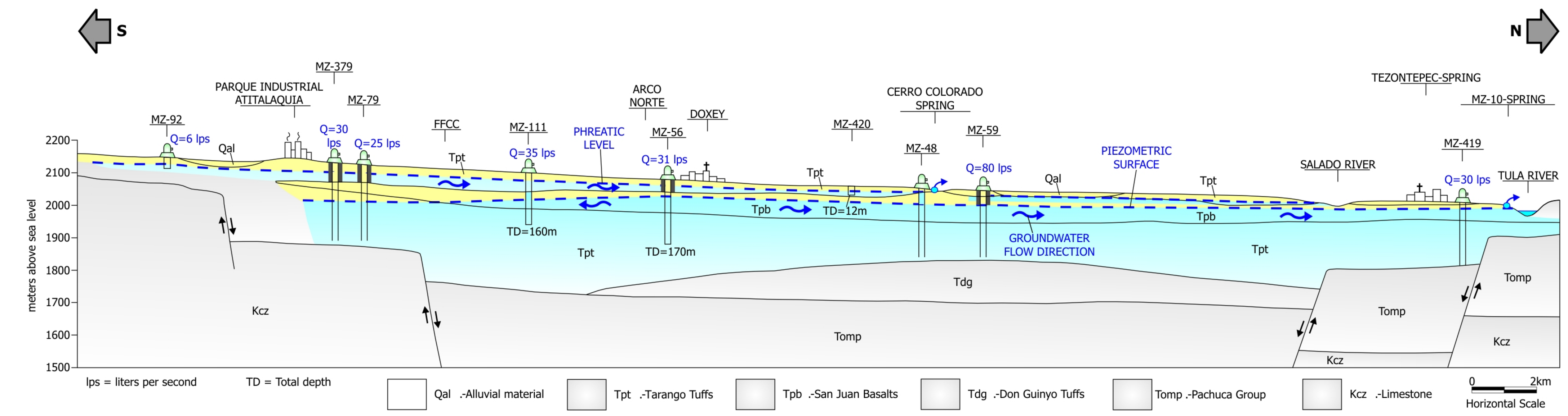

Figure 6. Shallow and deep aquifers in the Mezquital Valley. The shallow aquifer is in quaternary alluvial material. Deep aquifer is in tertiary tuffs and basalts. The aquitard in between is a clayey layer which is discontinuous throughout the valley

RESULTS AND DISCUSSION

Five VOCs and 9 SVOCs were detected in the wastewater used for irrigation. Only 2 SVOCs were detected in all the wastewater canals and groundwater sources, whereas no VOCs were detected in groundwater and springs.???

Of the 118 PhACs and the 7 reproductive hormones measured, 65 PhACs and 3 hormones were detected in the wastewater.

In groundwater sources, 23 PhACs were detected, mostly in the upper aquifer. Most of these compounds have low concentrations compared to those detected in canals.

There were only few detections and at lower concentrations in the deeper aquifers, which are used as groundwater supply (Fig. 6).

Shallow and deep aquifers in the Mezquital Valley. The shallow aquifer is in quaternary alluvial material. Deep aquifer is in tertiary tuffs and basalts. The aquitard in between is a clayey layer which is discontinuous throughout the valley allowing for some hydraulic connection between the aquifers at specific locations.
The concentration of the emerging contaminants observed in groundwater at the Mezquital Valley Aquifer, are very low compared to results in other regions where wastewater is also used for irrigation purposes (References****…..)

CONCLUSIONS

These results suggest that the subsurface acts as a filter, adsorbing and degrading most of the organic pollutant content in the infiltrated wastewater. A new wastewater treatment plant (PTAR Atotonilco) is being built to treat the wastewater prior to its release to the Mezquital Valley. The geochemical changes that this cleaner water will produce when infiltrated into the aquifer have not been assed yet.

REFERENCES

Downs, T.J., Cifuentes, E., Ruth, E. and Suffet I., 2000. Effectiveness of Natural Treatment in a Wastewater Irrigation District of the Mexico City Region: A Synoptic Field Survey. Water Environment Research, Vol. 72, No. 1:4-21.
Friedel, J.K, Langer, T., Siebe, C. and Stahr, K., 2000. Effects of Long-Term Waste Water Irrigation on Soil Organic Matter, Soil Microbial Biomass and its Activities in Central Mexico. Biology and Fertility of Soils, Vol., 31, No. 5: 414-421.
IMTA (Instituto Mexicano de Tecnologías del Agua), 2010. Análisis Técnico y Pruebas de Potabilización del Agua del Acuífero del Valle del Mezquital, en Diversos Municipios del Estado de Hidalgo. Report TC-1025.3).
Jimenez, B.E., Chavez, A., 2004. Quality Assessment of an Aquifer Recharged with Wastewater for its Potential USE as Drinking Source: "El Mezquital Valley" Case. Water Science and Technology, Vol. 50, No. 2: 269-276.
Jimenez, B.E., Chavez, A., Gibson, R., Becerril, J.E., Maya C. and Hernández, C., 2008. Complemento de la Caracterización del Agua de Consumo Humano en el Calle de Tula. Report, Instituto de Ingeniería, UNAM, Mexico.

Figure 4a. Sampling in underline canals

Figure 4b. Sampling in underline canals

Figure 5a. Sampling of Cerro Colorado Spring (60)

Figure 5b. Sampling of Tezontepec Spring (12)