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Research article

Endocrine disrupting compounds in streams in Israel and the Palestinian West Bank: Implications for transboundary basin management

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ABSTRACT

Endocrine disrupting compounds (EDCs) frequently enter surface waters via discharges from wastewater treatment plants (WWTPs), as well as from industrial and agricultural activities, creating environmental and health concerns. In this study, selected EDCs were measured in water and sediments along two transboundary streams flowing from the Palestinian Authority (PA) into Israel (the Zomar-Alexander and Hebron-Beer Sheva Streams). We assessed how the complicated conflict situation between Israel and the PA and the absence of a coordinated strategy and joint stream management commission influence effective EDC control. Both streams receive raw Palestinian wastewater in their headwaters, which flows through rural areas and is treated via sediment settling facilities after crossing the 1949 Armistice Agreement Line. Four sampling campaigns were conducted over two years, with concentrations of selected EDCs measured in both the water and the sediments. Results show asymmetrical pollution profiles due to socio-economic differences and contrasting treatment capacities. No in-stream attenuation was observed along the stream and in the sediments within the Palestinian region. After sediment settling in treatment facilities at the Israeli border, however, significant reductions in the EDC concentrations were measured both in the sediments and in the water. Differences in sedimentation technologies had a substantial effect on EDC removal at the treatment location, positively affecting the streams' ability to further remove EDCs downstream. The prevailing approach to addressing the Israeli-Palestinian transboundary wastewater contamination reveals a narrow perspective among water managers who on occasion only take local interests into consideration, with interventions focused solely on improving stream water quality in isolated segments. Application of the "proximity principle" through the establishment of WWTPs at contamination sources constitutes a preferable strategy for reducing contamination by EDCs and other pollutants to ensure minimization of public health risks due to the pollution of streams and underlying potable groundwater.

1. Introduction

Contamination of streams with toxic substances and their rehabilitation have received considerable attention during the last few decades (Bernhardt et al., 2007, 2005; Plumlee et al., 2012). While rehabilitation relies mostly on scientific knowledge, successful rehabilitation of transboundary streams also requires agreements between countries; thus, on many occasions, non-scientific considerations are incorporated into rehabilitation designs (Kallioras et al., 2006). There are many cases where bi- and multi-lateral conventions regulate actions to ensure that good water quality in joint basins is maintained, and water quantity is

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shared based on the needs of the parties (Fischhendler, 2007; Shmueli, 1999). Management of transboundary streams becomes especially complicated, however, when an asymmetry exists between the riparian states. Asymmetry can be found in the stringency and scope of local regulations (e.g., water quality standards), the financial abilities of the parties, political power, existing economic interests, etc. (Brochmann and Gleditsch, 2012; Shmueli, 1999). Such underlying asymmetry characterizes many of the transboundary streams that flow from the Palestinian Authority (PA) into Israel (Tal and Katz, 2012).

Most of the coastal streams in the central region of Israel originate in the highlands within the PA (Fig. 1). While 96% of the wastewater in Israel is treated before reuse or release into the environment (Cohen et al., 2016; Tal and Katz, 2012), only about 20% of the raw sewage produced within the PA (including much of the sewage produced in Israeli settlements) is treated within the PA. Another 14% of the wastewater from the PA is captured and treated in Israel, while the rest of the raw wastewater (66%) is eventually released to the environment with approximately a quarter of it into transboundary streams (Cohen et al., 2016, 2011). As a result, many of these naturally ephemeral streams that receive wastewater have become perennial, flowing year-round. The rapid population growth in the region (Tal, 2016a), the increasing demand for water, and the lack of major WWTP construction due to lack of funding or political conflicts (Tal and Katz, 2012) are all expected to cause further stream deterioration.

The flow of untreated wastewater in the streams that meander through Palestinian and Israeli rural and urban environments raises various concerns. The immediate concern to public health and livestock is related to direct contact with the water that contains pathogens and contaminants. Another concern is the percolation of wastewater and contaminants into the groundwater since most of the upper segments of these streams flow over a karst bedrock overlying the Mountain Aquifer (Avisar et al., 2009). This aquifer is one of the major water reservoirs in the region, providing water to both the Palestinian and Israelis with 128 and 402 million m^3/year, respectively (Cohen, 2016). Several studies on the water quality in these transboundary streams were conducted during the last decade (Abramson et al., 2010; Angel et al., 2010; Asaf et al., 2007; Lipchin, 2014). These studies consistently confirmed that while pathogen and nutrient loads were significantly reduced during the flow of sewage in the streams, most of the contaminants (70–90%) were not reduced to non-toxic levels, thus posing significant health risks. In addition, Abramson et al. (2010) surprisingly found that both Israelis and Palestinians revealed common restoration preferences, including a similar willingness to pay for restoration. None of the abovementioned studies, however, looked at the occurrence and fate of micropollutants, a suite of chemical compounds that are found in wastewater at relatively low concentrations and are often found in aquatic environments (Peng et al., 2008; Schwarzenbach et al., 2010).

EDCs are one major subgroup of micropollutants (Luo et al., 2014). EDCs refer to a diverse range of chemicals; their sources range from industrial products (e.g., plasticizers, flame retardants), consumer products (e.g., synthetic hormones, detergents), biocides (e.g., pesticides), animal and human secretions (e.g., natural hormones) to various transformation products of contaminants (e.g., octylphenol) (Luo et al., 2014). Considerable research has been directed at environmental exposure to EDCs because of the adverse risks they pose to reproduction and other critical physiological functions in humans and wildlife species (Futran et al., 2015). Most of the studies about EDCs in streams focus on their toxic effects and their fate along the streams (Acuña et al., 2014; Backhaus and Karlsson, 2014; Schwientek et al., 2016).

This study was designed in response to the severe gap in available information about the fate of EDCs in Mediterranean streams, especially on the sea's eastern side, and the implications for transboundary stream management in conflict regions. Local dynamics constitute an extreme case of how the release of EDCs upstream can affect communities downstream. Data are presented characterizing the EDC concentrations along two transboundary streams that originate in the Palestinian West Bank but soon cross

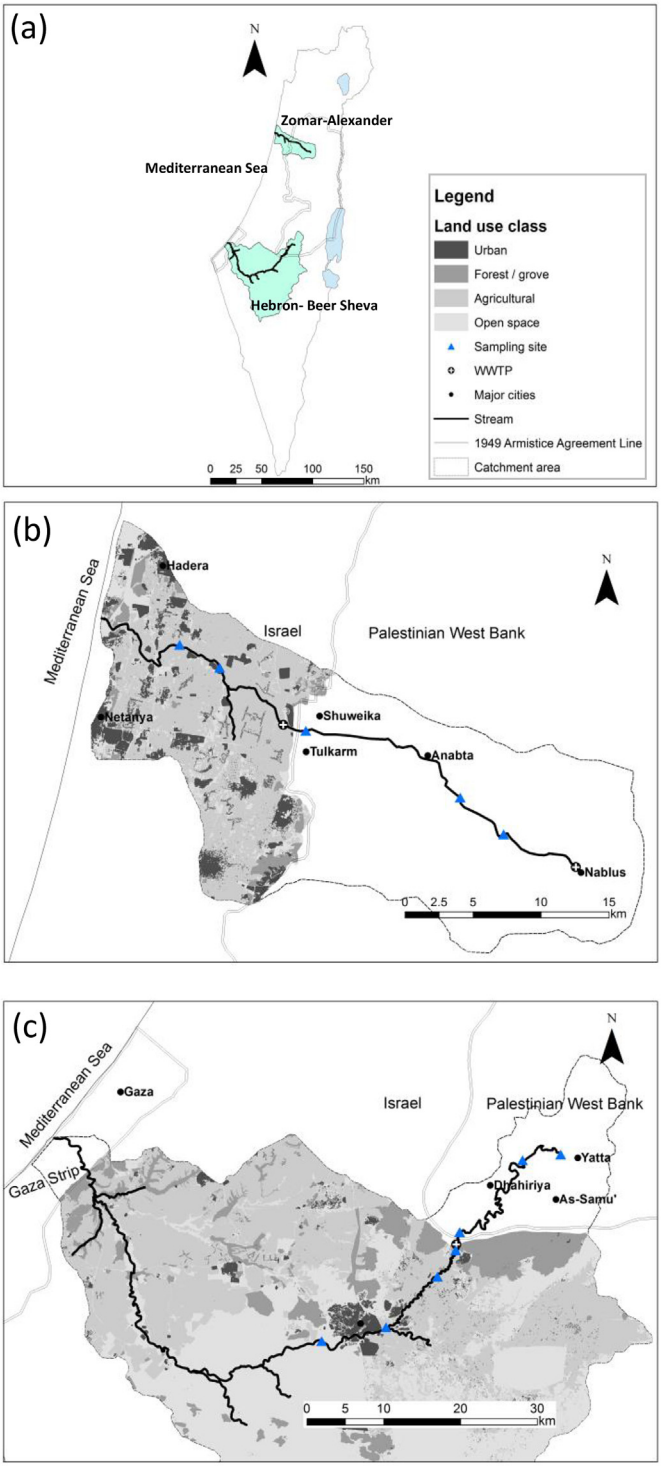

Fig. 1. Map of the study area showing borders and catchment boundaries (a), major cities, land use and sampling locations for the Zomar-Alexander (b) and the Hebron-Beer Sheva (c) catchments. Land use information in the PA was not available.