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Multidisciplinary approach to a study of water and bottom sediment quality of streams associated with mixed land uses: Case study Del Gato Stream, La Plata (Argentina)

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ABSTRACT

Surface water bodies receive a basin's wide diversity of pollutants, especially when there are mixed land uses. Among the many environmental tools to assess a body water quality, most studies use only a few. In addition these studies, usually, are focused only on a set of pollutants and an environmental matrix. The Del Gato Stream – a surface watercourse within of more populated area of Argentina – exemplifies the typically contrasting land uses around this area's streams. The predominant land uses along of the stream are agricultural in the upper, urban and industrial the middle, and animal husbandry in the lower subbasin. The aim of this study was to use a multidisciplinary approach to evaluate the environmental quality of that stream as a model of surface-water bodies within mixed-land-use regions in the Buenos-Aires metropolitan area. At each of the sampling sites – distributed along the stream as follows: 3 in the upper, 4 in the middle, 3 in the lower subbasin – general water parameters were measured; water and sediment samples taken for physical, chemical, microbiological, and ecotoxicological analysis; and the variables in each environmental matrix, analyzed separately and jointly. The stream presented a significant general deterioration, the middle subbasin with urban-industrial land use being the most impacted, where metals and metalloids recorded highest levels, and the rest of the measured parameters were also found at high levels. The upper subbasin had the highest quality, and the lower subbasin proved poor quality regarding microbiological variables, nutrients, and general water parameters. The tests included in the toxicity battery did not reflect a common pattern of toxicity along the watercourse. However, when they were integrated in the EDAR index, the middle subbasin was the most affected sector of the stream. Although, the usefulness of each analysis tool must be evaluated taking into account the objective of the study, if the aim is to know the general environmental quality of a stream, the multiple-factor analysis proved to be the most effective means in complex systems under the influence of great diversity of pollution sources. This study provides relevant information about the ecological quality of a stream representative of a region with scarce environmental information.

1. Introduction

The exponential increase in the world population, its concentration in large urban centers, and the gamut of anthropic activities involved in meeting its demands (industrialization, agriculture, raising livestock), all contribute to the present imbalance in natural systems resulting from an increase in sewage drainage, urban and agricultural runoff, and technological advances that release synthetic products into the environment (Seilheimer et al., 2007; Zeitoun et al., 2014; Miao et al., 2015). Large urban settlements have historically been closely linked to water sources that are used as resources for the subsistence of populations, and in turn, become the ultimate receptacle of the by-products and waste materials from most human activities. Therefore, anthropic activities disturb the natural state of water resources with resulting detrimental effects on the associated biota and, in turn, on the human effector populations themselves (Ronco et al., 2008; Peluso et al., 2013a; Mugni et al., 2015).

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The evaluation of the quality of water bodies is approached by different disciplines within the environmental sciences. The environmental physical chemist uses the concentration of compounds and other indirect variables to characterize the quality of a resource. The microbiologist, analyzes water quality based on the presence and relative abundance of different functional groups, even up to identifying the specific nature of a contamination from a determination of the taxa present; whereas the ecotoxicologist, in studying the biologic effects of pollutants on organisms, provides a simple and practical way of estimating the quality of water systems (APHA, 1998; Environment Canada, 1999; Newman and Clements, 2008). Regardless of the environmental approach used, the difficulty of the study increases with the diversity of land uses in a given basin (Islam et al., 2015). In such instances, a combined approach is needed to determine the overall environmental quality of water bodies and implement the appropriate management policies for their recovery.

Previous experience dictates that contaminated urban rivers can be recovered if technical, economic, and human resources are implemented adequately under coordinated and long-term, sustained policies, with the Thames River being an example of this principle (Sheehan et al., 1984). A proper design of remediation strategies requires a precise diagnosis of the socio-environmental situation in order to facilitate decision-making and avoid unsuccessful activities, and even more so in developing countries such as in the example of Argentina, where decision-making in terms of environmental policies is faced with characteristic socioeconomic problems.

Most of the studies involving the environmental diagnosis of surface water bodies do not analyze the quality of the water and bottom sediments in a comprehensive way (Sekabira et al., 2010; Zhang et al., 2010; Azhar et al., 2015); and when such investigations do, they usually take into account the groups of compounds associated with only one or just a few of the sources of pollution (*i.e.*, urban, industrial, agricultural) (Islam et al., 2015; Etchegoyen et al., 2017).

Buenos Aires city and its metropolitan area clearly exemplifies the process of transformation from an initial geographic area of high social and economic prosperity to a mega-urbanization with extensive problems of territorial planning and the occupation of the land along with the concomitant pollution of the water resources (Vapñarsky, 2000). The repeated social, economic, and financial crises in this country generated large settlements of low-income populations with significant shortages of the basic utilities such as electricity, drinking water, sewage, and rain-drainage networks (INDEC, 2010). Some of these emergency settlements were installed on marginal areas near watercourses, generating the uncontrolled growth of urbanization in the absence of a bioholistic vision by the territorial-planning and environmental-control agencies that allowed the establishment of those settlements along with the gradual development of prodigious cities and industrial poles without clear guidelines for urban planning.

The Buenos-Aires area contains a large number of stream microbasins that cross the urban centers in west-east direction before flowing into the Río de la Plata estuary. Most of these minicatchments have a high degree of anthropization, including agricultural areas (generally around the headwaters), industries, and an extensive urbanization (usually in the middle and lower sections) (Banda-Noriega and Ruiz de Galarreta, 2002). Many of these streams have been partially channeled and/or piped with the flood plains being occupied by houses that are therefore frequently flooded.

The Del Gato Stream exemplifies, on a small scale, the variability of activities and conflicts of land use that occur in a basin of that type, being fraught with problems common to other regional basins that cross rural, suburban, and urban areas.

Within this context, the aim of this study was to evaluate through several indicators, the physical, chemical, microbiological and ecotoxicological quality of the water and sediment of Del Gato Stream, as a case study of water bodies surrounded by mixed uses of the land.

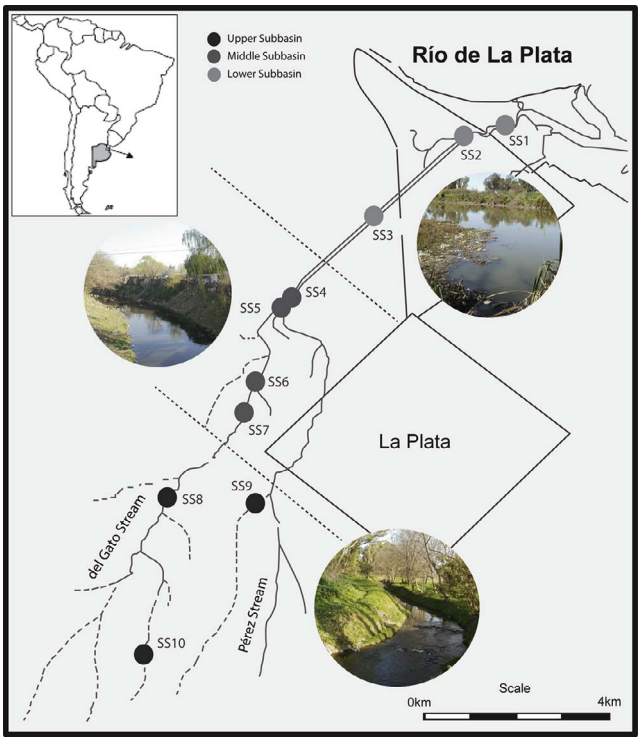

Fig. 1. Scheme of the course of the Del Gato Stream used as a model example of the environmental quality of surface water bodies surrounded by mixed land uses within the Buenos-Aires metropolitan area. The locations of the ten sampling sites and the limits of the subbasin are indicated. The associated photographs illustrate the general characteristics of each subbasin within the vicinity of the stream.

2. Materials and methods

2.1. Study area

The basin of the Del Gato Stream – with an area of approximately 98 km^2 and a length of 25 km – is a typical plains stream of the Río de la Plata basin with a general southwestern-northeastern runoff course. In many sectors, the Del Gato has been rectified to allow normal drainage to the estuary. In the lower sector of the middle subbasin, the stream receives input from the Regimiento and Pérez streams, which are incorporated into the underground drainage system in the urban areas (Guimaràes et al., 2009). Almost 380,000 people live in the Del Gato floodplain, with housing in many instances located on the stream's banks (Bazán et al., 2011; Fig. 1).

Studies carried out by Andrade et al. (2012) indicated that in the basin of the Del Gato Stream a conflict existed between the informal and the correct legal uses of the bordering land. The upper subbasin is characterized by agricultural use combined with discontinuous residence along with a very low industrial activity; the middle subbasin is the most intensively populated with the greatest concentration of industrial activity; while the lower subbasin involves the raising and grazing of livestock (*i.e.*, farm-animal husbandry) along with discontinuous residential areas, low industrial activity, and an open-pit landfill (Fig. 1).

2.2. Sampling sites

The sampling was carried out during in November 2011. The sampling sites (SSs) have been located according to the different land uses within the stream's basin. Thus, the SSs 1, 2, and 3 are characteristic of the lower subbasin; 4, 5, 6, and 7 represent the most complex sector of the watercourse because of the multiplicity of land uses (middle subbasin); while 8, 9, and 10 exemplify the activities associated with the