What kind of tools can we use to outline the urban river pollution in an emerging megacity? Example of Chennai (Tamil Nadu, India)

De quels outils dispose-t-on pour caractériser la pollution d'un fleuve urbain dans une mégapole émergente? Exemple de la ville de Chennai (Tamil Nadu, Inde)

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RÉSUMÉ

Deux fleuves côtiers, Cooum et Adyar, drainent la mégapole de Chennai (Tamil Nadu, Inde, 12 millions d'habitants). Ils reçoivent à la fois les eaux usées non traitées, celles des stations d'épuration après traitement, des égouts issus de différentes infrastructures de la ville et du lessivage de chaussées. Des sédiments de fond ont été échantillonnés dans ce gradient urbain sur une distance de plusieurs kilomètres depuis la zone amont semi-rurale jusqu'à la zone estuarienne à travers la zone la plus urbanisée de Chennai. Les concentrations en éléments majeurs ont été analysées tout comme plusieurs paramètres sédimentologiques. Un nouvel indice géochimique urbain est proposé pour expliciter ce développement urbain et industriel, bien souvent anarchique. Les variations spatiales des concentrations d'éléments tels que l'argent, le chrome, le cadmium sont des traceurs représentatifs de ce gradient de contamination d'origine urbaine. De plus, une mousson centennale a eu lieu en Décembre 2015. Le réseau de la Cooum a complétement été inondé et celui de l'Adyar a vu son niveau augmenter à plein bord à cause des lâchers depuis le réservoir principal situé en amont. La comparaison des concentrations dans les sédiments de 2015 et 2016 permet de mieux identifier les facteurs contrôlant ce gradient longitudinal de contamination urbaine

ABSTRACT

Two main rivers, Cooum and Adyar rivers, drain the growing megacity area of Chennai (Tamil Nadu, India; 12 million inhabitants). These rivers are discharging sewage, waste water and runoff water conveyors and several smaller outputs of untreated waters. Bed sediments of both urban rivers were collected in a urban gradient over a distance of several kilometers from semi-rural upstream location to the mouth of the rivers and crossing the most urbanized part of the city (major and trace elements, grain size and sedimentological preliminary measurement were detected). A new proposed Grosbois/Geochemical Urban Footprint Index is triggered by the development of non-planned urbanization and urban industry. Silver, chromium, cadmium, mercury are the most significant tracers of an urban contamination gradient at the Chennai megacity scale. Samples were collected in 2015 and 2016 during the dry season. However, unusual centennial intense monsoon in December 2015 provided huge flood events in Chennai. The Cooum urban basin was completely overflooded and water level of the Adyar river increased due to high discharge of the major upstream reservoir. The comparison between the 2 sediment surveys made it possible to identify main factors controlling the longitudinal gradient of contamination.

MOTS CLES

Pollution, fleuves urbains, mégapoles, empreinte géochimique – pollution, urban waters, megacities, geochemical footprint

1 CONTEXT AND OBJECTIVES

In India there are many urban river systems supplying water to huge service area. In the recent decades due to the industrial explosion/human overpopulation and aggravated pollution, these hydrosystems are in endangered situation including the impact on the ecosystem in those rivers. Urbanisation and industrialization put deep and irreversible impact on aquatic systems which are the life supporting tool of future generation, need to protect them is the current and urgent need.

In this study an attempt is made to ascertain the present status of the Adyar and Cooum river, the most important rivers in Chennai, the capital of Tamil Nadu, India. An intensive study is also conducted to find out the sources and transfer of the pollution by trace elements across the river stream. The aim of this study is to be establish an upstream-downstream characterization of the fluvial system, including influents and tributaries of identifying potential agricultural, industrial and urban sources of incoming pollution.

2 MATERIAL AND METHODS

Bed sediment and flood deposit samples were collected from 25 sampling stations in the two urban rivers of the megacity of Chennai by using an uwitec coring device in February 2015 and February 2016, after a huge flooding event. The samples were retrieved from upstream to downstream and sampling sites were selected on the basis of potential point sources (industry and urban sewages) and accessibility. The samples were immediately transferred to plastic-sealed bags using plastic scoop and stored at 4ºC in an icebox. In the lab, after removing the coarse shell fragments and visible organisms, sediments were dried at 60ºC in a well-ventilated oven. Material was completely digested with $LiBO_2$-$Li_2B_4O_7$ on a tunnel oven and placed in an acidic solution. The residues were completely re-dissolved with HNO_3 acid. Total contents of major and minor elements were analyzed by ICP-AES, trace elements by ICP-MS (Perkin Elmer 5000) except Hg, done by cold vapour AAS (Perkin Elmer 5100). All the digestion process and analysis were quality-checked by analysis of sample duplicates and internal reference materials (Dhivert et al., 2015). Accuracy was within 5% of the certified values and analytical errors better than 10% RSD for trace elements concentrations, at least 30 times higher than detection limits. The intensity of heavy metal contamination can be evaluated by Geoaccumulaion Index (Igeo) and it was first proposed by (Muller 1969). It is mathematically expressed as,

$$I_{geo} = \log_2\left(\frac{Cn}{1.5\ X\ Bn}\right)$$

Where, C_n is the measured concentration of trace element in the sediment and B_n is the geochemical background concentration of element.

3 RESULTS AND DISCUSSION

Cooum and Adyar rivers are the main water bodies in Chennai. These rivers are moderately to extremely polluted with regards to trace elements accumulated. Ag, Cd, Hg and Sn present the highest Igeo value, when compared to As, Cr, Cu, Ni, Pb, Sb, U, W and Zn. For the estimation of anthropogenic inputs, this study identified an urban tracer by using new specific index for Geochemical Urban Footprint Index (GUFI) and Metal Urban Index (MUI). The GUFI is based on the concentration of Silver (Ag), Cadmium (Cd), and Mercury (Hg), some of the most commonly analysed toxic trace element in the urban environment.

$$\text{Geochemical Urban Footprint Index (GUFI)} = \left\{\frac{(MUI)_{Ag}+(MUI)_{Cd}+(MUI)_{Hg}}{n}\right\}$$

Where, $(MUI)_{Ag}$, $(MUI)_{Cd}$ and $(MUI)_{Hg}$ is the metal urban index for Ag, Cd and Hg and n is the number of metal urban index. The GUFI can be classified as six categories of contamination such as 1-10 extreme low; 10-25 low; 25-50 moderate; 50-75 strong; 75-100 high; >100 extremely high contamination. (fig. 1). It is reasonable to assume that the increased concentrations of trace elements in the sediments of the river is correlated to direct discharge of industrial, urban and domestic waste in the rivers. Trace elements are introduced into Cooum River via various sources such as domestic waste, industrial effluent, urban run-off, atmospheric deposition, as well as upstream run-off accumulate into the sediments.

4 RECOMMENDATION AND GUIDANCE

The results of this study indicates that monitoring and immediate managerial measurement must be taken to avoid further potentially toxic metal pollution of river sediment. Continuous monitoring and further studies are recommended to ascertain long-term effects of heavy metals on environment. Future investigation is also suggested for seasonal variability of toxic metals in this water bodies to mitigate the pollution of the water resources of the Chennai megacity.

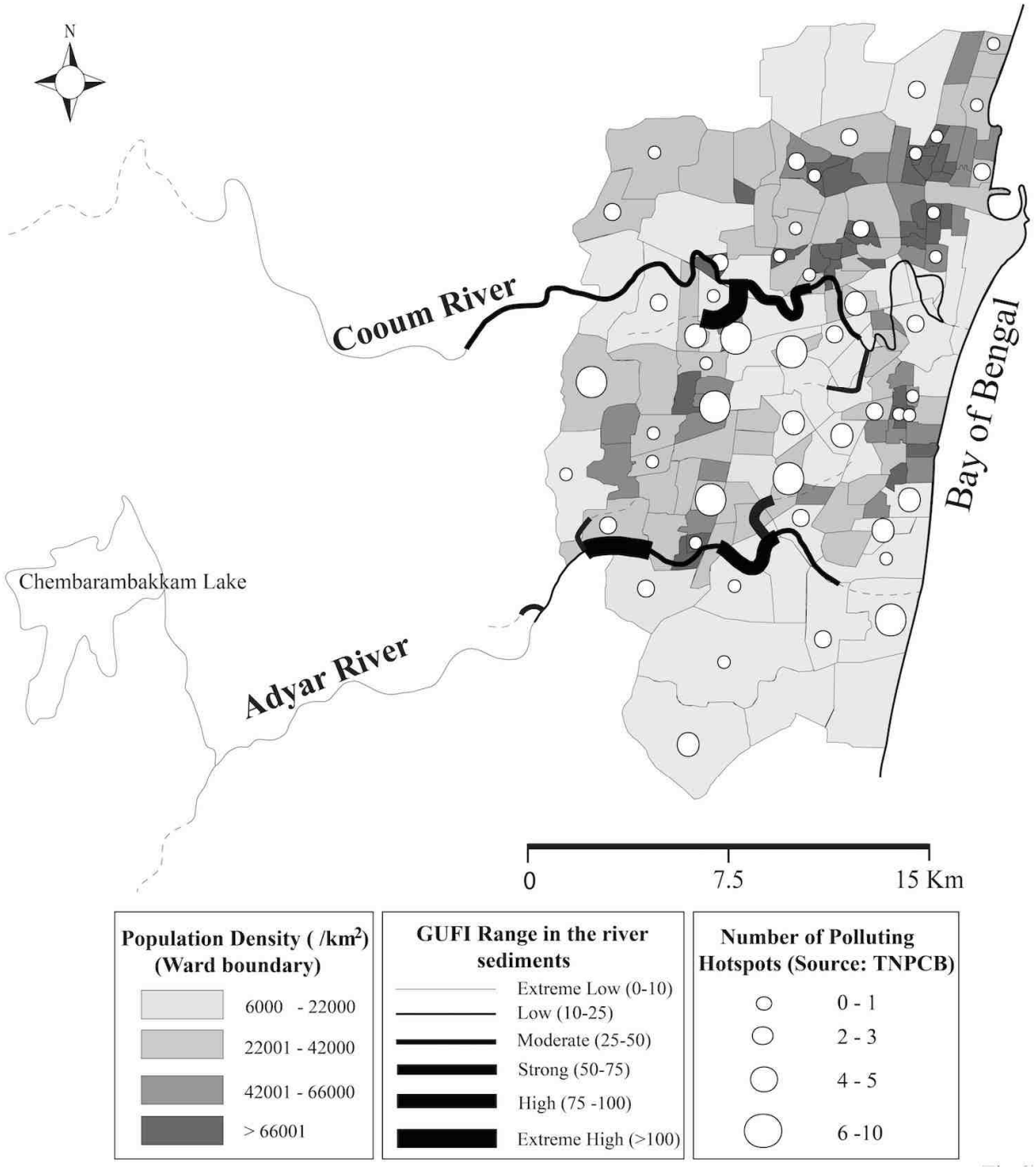

Figure 1 : Current geochemical urban footprint index of the two urban in the Chennai megacity regarding population density and polluting hotspot

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