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Occurrence of human-excreted contaminants within a decantation tank: a clue of historical consumption?

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The Earth system is enduring a unique transition in its history due to the pregnancy of human activities on geological processes compared to natural controls. A large community examines the extent to which these activities will be archived in the sedimentary record and remain for millions years within a new geological era named Anthropocene. Here we explore the potential of sediments that accumulated in sewer systems for such a record of human posterity, considering that urban socio-ecosystems are prone to a large diversity and high concentrations of potential tracers of human activities [1].

The selected site is a decantation tank that collects wastewater and stormwater from the sewer network of the northern part of Orléans (France). This 20 m deep underground building of cylindrical and conical shape was constructed in 1942 and was reputed to have not been subjected to any clean out operation (COO) since that time. 5 cores (i.e. 8m of sediments) were acquired from 2014 to 2017 by manually inserting a plastic tube in the outcropping sediments or with a gravity corer prior to COO.

152 samples were taken and investigated in this work. These samples were extracted with a mixture of water:methanol (1:1) in order to obtain drugs and illicit drugs that were then quantified by HPLC-MS². Extracted sediments then underwent a large range of classical sedimentological analyses (e.g. granulometry, facies description). Total organic carbon, Hydrogen Index, Oxygen Index and Tmax were determined by Rock-Eval pyrolysis. The age model is based on 47 ¹⁴C dates obtained on the 6 cores and computed with OxCal v4.3.2 and Bomb13NH1 calibration curve.

Oldest sediments are dated back to 1970. This reveals that COO certainly took place at the end of the seventies, with no administrative or written record subsisting. Sedimentation rates are then very high with 6 m deposited in two years, which corresponds to accumulation rates observed after the 2015 COO. Then, sedimentation rates slowed down with only 2.5 m accumulated from 1980 to 2014 because the decantation tank was saturated and could not accumulate more sediments. Hence, repeated episodes of erosion compensated by deposition are suspected over that period. Sediments are stratigraphically organised into organic (TOC > 2%) and mineral (TOC < 2%) layers resulting from wastewater and stormwater inputs, respectively.

Among the 27 investigated drugs and illicit drugs, some compounds such as ciprofloxacin, ofloxacin or tetrahydrocannabinol could not be detected in the sediments. For the other detected compounds, a strong control of speciation on the presence and concentration of drugs and illicit drugs is evidenced [2].

Neutral and anionic compounds (e.g. carbamazepine, salicylic acid) present higher occurrences in the organic facies whereas cationic compounds (e.g. codeine, benzoylecgonine) display more regular occurrences, whatever the facies. The distribution of non-cationic molecules is therefore directly correlated with the distribution of organic carbon, whereas for the cationic ones, a correlation with the relative abundance of inorganic surfaces is evidenced. As a result, the interaction mechanisms between targeted compounds and the sedimentary composition appears to be the most important control of their occurrences (Figure 1). Finally, for some compounds such as cocaine and MDMA, the concentration decreases with the depth, indicating a potential degradation pattern. This type of pattern is for example emphasized by the relative increase of the benzoylecgonine/cocaine ratio with depth (*i.e.* benzoylecgonine is one of the main metabolite of cocaine, less sensible to degradation).

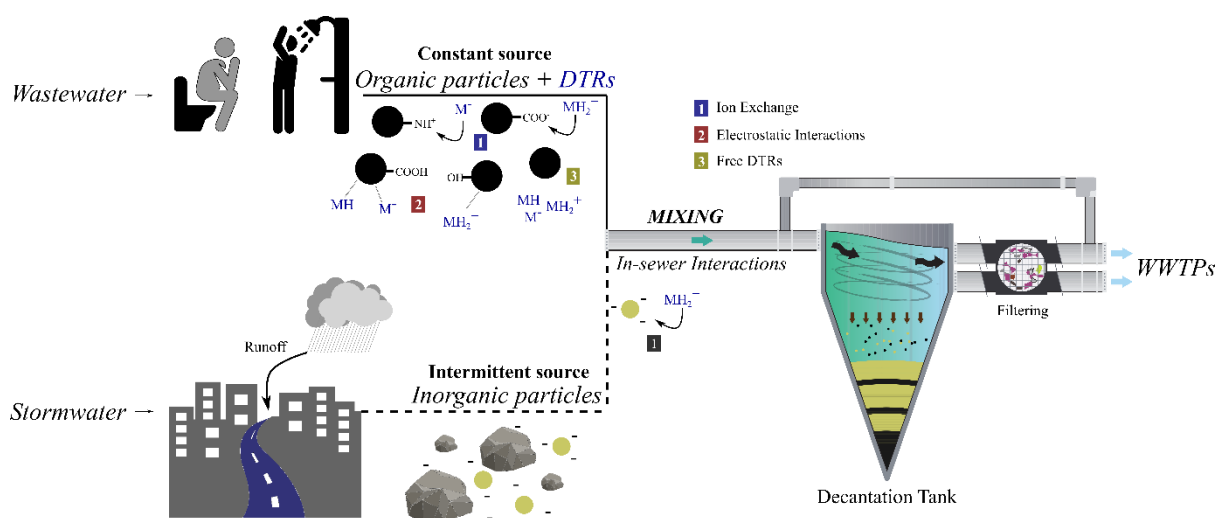


Figure 1 Schematic representation of the origin and possible reactivity of solids samples in the decantation tank.

The analysed sediments present important vertical variations of composition, due to distinct origin (*i.e.* wastewater/stormwater), especially emphasized by the organic carbon variations. Hence, drugs and illicit drugs distributions appear to be strongly controlled by their theoretical affinity with solids. As a result, the distribution of these compounds with time cannot be directly correlated with the evolution of excretion amount in the catchment, as initially expected. Nevertheless, these patterns are very informative on the affinity between sediments and organic contaminants at a larger scale.

References

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