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25. Limnological and hydro(geo)logical advances for mid-sized lakes as a water resource for the next century

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25. Limnological and hydro(geo)logical advances for mid-sized lakes as a water resource for the next century

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25.1

Micropollutant dynamics in Vidy Bay- a coupled hydrodynamic-photolysis model to assess the spatial extent of ecotoxicological risk

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The direct discharge of wastewater (WW) effluent into the Vidy Bay of Lake Geneva results in the seasonal formation of an effluent plume containing locally high concentrations of wastewater-derived micropollutants. A 10-month sampling campaign showed that the plume depth followed the thermocline, which moved to greater depths over the course of the warm seasons. In absence of thermal stratification, between November and January, the plume surfaced or was not detected due to enhanced mixing of the water column. The high concentrations of micropollutants near the wastewater treatment plant (WWTP) outfall present a potential ecotoxicological risk, yet the spatial extent of the risk zone remains unclear.

This work couples the two main processes affecting the spreading of the plume, namely water hydrodynamics and photolysis. The concentration of micropollutants around the wastewater outfall was predicted for typical wind scenarios and seasons relevant in Vidy Bay using a coupled hydrodynamic-photolysis model. Specifically, we experimentally determined the photolysis quantum yields and indirect photolysis rate constants for 24 wastewater-derived micropollutants (mainly pharmaceuticals), and implemented this data into a hydrodynamic particle tracking model, which tracked the movement of water parcels ("particles") from the WWTP outfall through the Vidy Bay. Modeling results were validated with monthly field measurements collected in 2010.

Model results showed that the zone of potential ecotoxicological risk was generally larger under stratified (summer) conditions than under well-mixed (winter) conditions. This could be attributed to slower dilution, as well as decreased photodegradation due to the entrapment of the WW plume below the thermocline. The largest extent of the risk zone was observed under conditions of Bise (north-easterly wind) during the summer season, with a westward expansion of > 300m. Under Vent (south-westerly wind) conditions, the area of risk was generally smaller and extended mainly to the east (upstream) of the WWTP. As expected, photodegradation was an important removal mechanism for many compounds and thus contributed to a reduction in the ecotoxicological risk over time and distance from the WW outfall. The mixture toxicity near the outfall was dominated by five substances, mainly antibiotics. The coupled photolysis-hydrodynamic model revealed that the risk zone may affect a stretch of up to 600 m in proximity to the shore (ca. 300 m in east and west direction of the WW outfall). This zone should be targeted in future studies of the ecotoxicological effects of WW effluent in Vidy Bay.

25.2

Coastal sediments: sink or source of pollution? A case study (Toulon bay, SE France)

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The highly contaminated sediments from Toulon bay (France, NW Mediterranean Sea, Tessier et al., 2011) were deeply studied to investigate their potential threat toward the seawater quality. In such context, analytical and modelling approaches were used to better understand the dynamic and fate of diagenesis tracers and inorganic contaminants in coastal sediments. Core sediments were sampled through the bay every 2 months, for 1.5 years to characterize porewater (physical/chemical parameters, diagenesis tracers and major/trace concentrations …) and solid sediments (major/trace contents, selective extractions and carrier phase identification). A 1D steady-state modelling approach (PROFILE, Berg et al., 1998) was used to fit the elements' profiles, estimating depth reaction intervals and reaction rates. Thermodynamic simulation (PHREEQC, Parkhurst & Appelo, 1999) was also performed to calculate elements' chemical speciation. Laboratory simulations of sediments resuspension were carried out at various solid/liquid ratios of surface and anoxic sediments (0-2 cm and 20-22 cm, respectively), aiming at considering the risk of contaminant mobilization through events of various magnitudes.

The element dissolved profiles showed significant seasonal variations. The highest diagenesis activity was recorded in November and March, suggesting a link with the varying input of "fresh" organic matter (e.g. plankton bloom). Otherwise, the coupling of experimental (selective extractions) and modelling approaches demonstrated the strong link between contaminants and the diagenesis-sensitive phases in subsurface sediments. The most recurrent examples were the coupling of As/Fe oxides and Co/Mn oxides. Precisely, the estimation of the Fe and As quantity lost or gained through different diagenetic processes (mineral dissolution/precipitation or adsorption…) demonstrated a correlation with a Fe/As ratio of 230. Selective extractions have also underlined that As was mainly linked to amorphous iron oxyhydroxide. The relationship between As and this diagenetic-sensible mineral explained the important As remobilization in subsurface sediment. The estimated As diffusive flux from sediments is then significant (i.e. ~1.6 ng_{As} cm^{-2} d^{-1} in July 2009).

The simulations experiments of sediments resuspension showed a high risk of pollutants remobilization. The mechanisms of these phenomena (oxidation and/or formation of new carrier phases, adsorption/desorption of pollutants…) seemed to be element-dependant while the sediments characteristics appear to control the remobilization amplitude. For all cases, the trace element concentrations reached at the maximum of remobilization exceeded the toxicity levels for microorganisms (e.g. plankton).

The monitoring of the diagenetic activity showed a significant seasonal modification of the behaviour of numerous elements, either diagenetic tracers or inorganic contaminants. A high mobilization of such contaminants in subsurface sediments, resulting in a significant diffusive flux toward seawater, could turn the sediments a potential pollution source. In parallel, sediments suspension events (storm, nautical traffic, dredging operations…) were also demonstrated to be active pollution incidents. Being not only an ultimate sink of contamination in a surrounding ecosystem, sediments must be also considered as a passive/active source of pollution.

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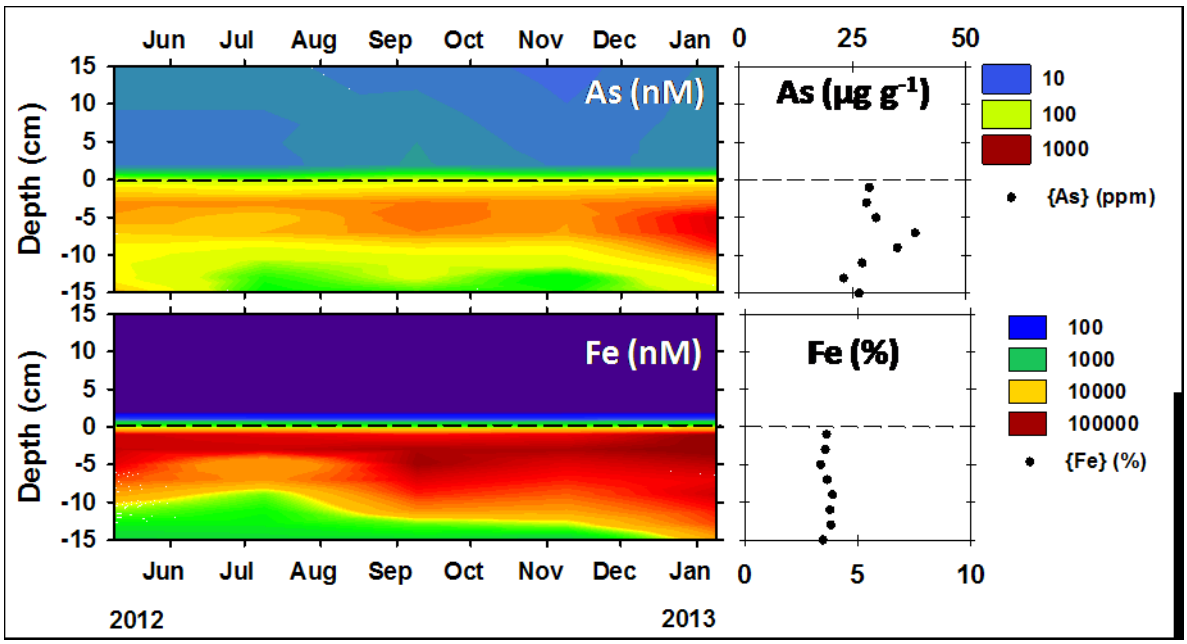

Figure 1: Monitoring of As and Fe concentration in sea/pore water and sediments.

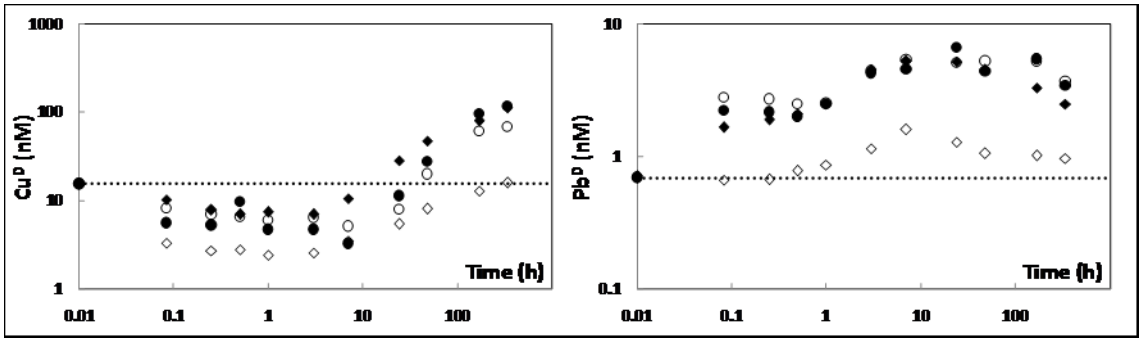

Figure 2: Dissolved Cu (left) and Pb (right) concentration remobilized during resuspension experiments of surface (diamond symbol) and anoxic (circle symbol) sediments. The solid/liquid ratio was close to 0.1 (open symbol) and 1 (full symbol) g L^{-1}.

25.3

Diffuse transfer of the herbicide glyphosate from the Lavaux vineyards to the Lake of Geneva: Dynamics and environmental risk assessment.

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The use of herbicides in agriculture may lead to environmental problems, such as surface water pollution, with a potential risk for aquatic organisms. The herbicide glyphosate is the most used active ingredient in the world and in Switzerland. In the Lavaux vineyards it is nearly the only molecule applied. This work aimed at studying its fate in soils and its transfer to surface waters.

First of all, an analytical method using ultra performance liquid chromatography coupled with tandem mass spectrometry (UPLC-MS/MS) was developed for the trace level quantification of this widely used herbicide and its main by-product, aminomethylphosphonic acid (AMPA). The method was validated for the matrix effect correction in relevant environmental samples, with limits of detection and quantification as low as 5 and 10ng/l respectively.

In the field, two parcels of the Lavaux vineyard area, located near the Lutrive River at 6km to the east of Lausanne, were monitored to assess to which extent glyphosate and AMPA were retained in the soil or exported to surface waters. They were equipped at their bottom with porous ceramic cups and runoff collectors, which allowed retrieving water samples for the growing seasons 2010 and 2011. Results revealed that the mobility of glyphosate and AMPA in the unsaturated zone was likely driven by the precipitation regime and the soil characteristics, such as slope, porosity structure and layer permeability discrepancy. Elevated glyphosate and AMPA concentrations were measured at 60 and 80 cm depth at parcel bottoms, suggesting their infiltration in the upper parts of the parcels and the presence of preferential flow in the studied parcels. Indeed, the succession of rainy days induced the gradual saturation of the soil porosity, leading to rapid infiltration through macropores, as well as surface runoff formation. Furthermore, the presence of more impervious weathered marls at 100 cm depth induced throughflows, the importance of which for the lateral transport of the herbicide molecules was determined by the slope steepness. Important rainfall events (>10 mm/day) were clearly exporting molecules from the soil top layer, as indicated by important concentrations in runoff samples. A mass balance showed that total loss (10-20%) mainly occurred through surface runoff (96%) and, to a minor extent, by throughflows in soils (4%), with subsequent exfiltration to surface waters (Fig.1).

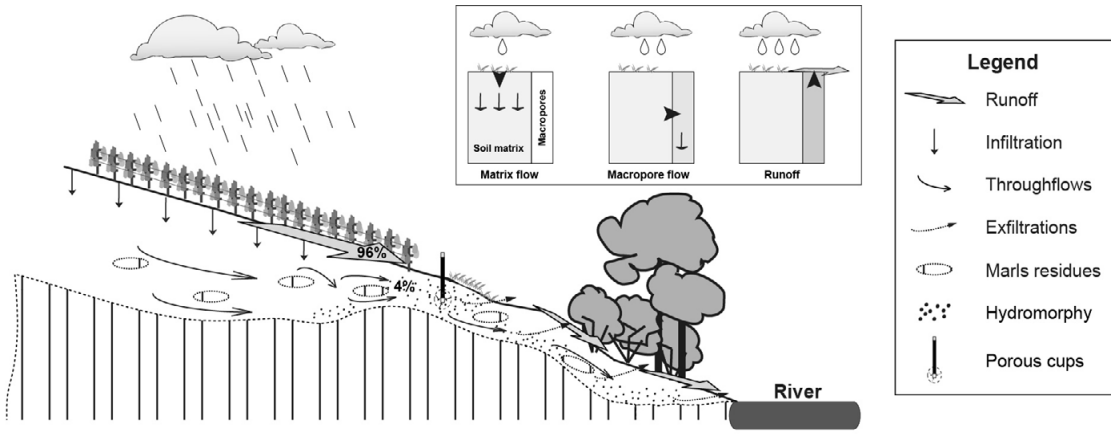

Figure 1. Synthesis of water pathways in vineyard parcels responsible for the diffuse export of glyphosate and AMPA molecules in the river direction.

Observations made in the Lutrive River revealed glyphosate and AMPA dynamics at the catchment level, which strongly depend on application rates, precipitation regime, land use and also on the presence of drains or constructed channels. Elevated concentrations, up to 4970 ng/l, observed just after the application, confirmed the diffuse export of these compounds from the vineyard area by surface runoff during main rain events (Fig.2A). From April to September 2011, a total

load of 7.1 kg was calculated, with 85% coming from vineyards and minor urban sources and 15% from arable crops. Small vineyard surfaces could generate high concentrations of herbicides and contribute considerably to the total load calculated at the outlet, due to their steep slopes (~10%). The extrapolated total amount transferred yearly from the Lavaux vineyards to the Lake of Geneva was of 190kg. Lastly, based on maximum concentrations measured in the river, an environmental risk for these compounds was assessed, using laboratory tests and ecotoxicity data from the literature (Fig.2B). In our case and with the methodology applied, the risk towards aquatic species was found negligible (RF<1).

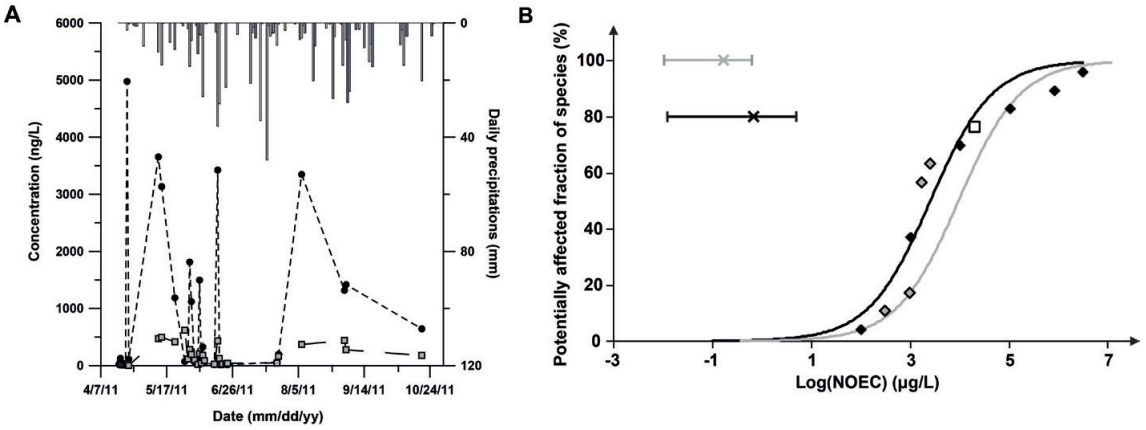

Figure 2. A: Glyphosate (●) and AMPA (□) concentrations at the Lutrive River outlet from April to October 2011 and daily precipitations; B: Species Sensitivity Distribution (SSD) curves for glyphosate (black line) and for AMPA (grey line). Their minimum, maximum and mean concentrations measured in the Lutrive River are represented on the top left of the figure.

25.4

Effects of oligotrophication on primary production in peri-alpine lakes

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During the second half of the 20th century untreated sewage released from housing and industry into natural waters led to a degradation of many freshwater lakes and reservoirs worldwide. In order to mitigate eutrophication, wastewater treatment plants, including Fe-induced phosphorus precipitation, were implemented throughout the industrialized world, leading to reoligotrophication in many freshwater lakes. To understand and assess the effects of reoligotrophication on primary productivity, we analyzed 28 years of 14C assimilation rates, as well as other biotic and abiotic parameters, such as global radiation, nutrient concentrations and plankton densities in peri-alpine Lake Lucerne, Switzerland. Using a simple productivity-light relationship, we estimated continuous primary production and discussed the relation between productivity and observed limnological parameters. Furthermore, we assessed the uncertainty of our modeling approach based on monthly 14C assimilation measurements using Monte Carlo simulations. Results confirm that monthly sampling of productivity is sufficient for identifying long-term trends in productivity and that conservation management has successfully improved water quality during the past three decades via reducing nutrients and primary production in the lake. However, even though nutrient concentrations have remained constant in recent years, annual primary production varies significantly from year to year. Despite the fact that nutrient concentrations have decreased by more than an order of magnitude, primary production has decreased only slightly. These results suggest that primary production correlates well to nutrients availability but meteorological conditions lead to interannual variability regardless of the trophic status of the lake. Accordingly, in oligotrophic freshwaters meteorological forcing may reduce productivity impacting on the entire food chain of the ecosystem.

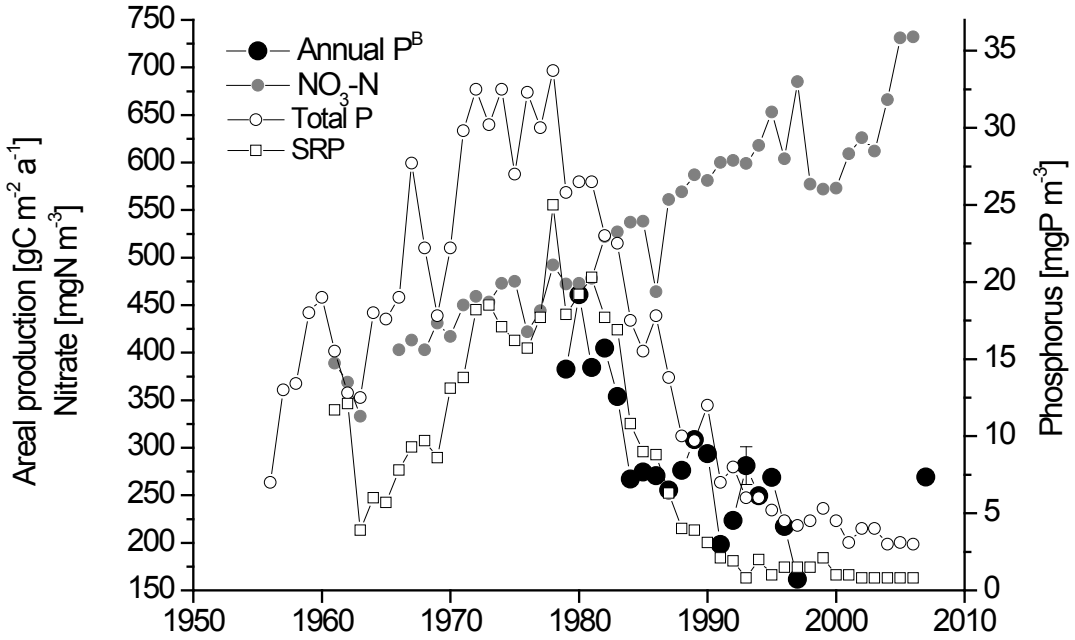

Figure 1. Long-term development of nutrients concentrations and annual productivity in Lake Lucerne. The legend in the top left corner describes the symbols. (Figure from Finger et al., 2013)

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25.5

Evaluation of pollutants inputs from large agglomeration to the coastal zone: the case of Marseille (France)

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Only a few studies have dealt with the Mediterranean area despite its rapid anthropization due to present-day heliotropism from Northern Europe and despite its climate specificities. Among all the possible sources of marine pollution, large coastal cities are among the most worrying, especially in the Mediterranean Sea. A typical example is Marseille, the largest Mediterranean French city, with over 1.7 million inhabitants. Two small rivers, the Huveaune and the Jarret, run through the agglomeration and join before their outlet to the sea. The uniqueness of this system is that the river waters are mixed with the city waste water treatment plants (WWTP) effluents and then rapidly discharged into the open sea without passing through an estuary, so that the WWTPs' contribution to the water characteristics at the outlet is most likely predominant during baseflow periods. These inputs have a certain impact on the local coastal ecosystem, however, a high number of such anthropized sources along the coast is likely to impact the whole Mediterranean Sea.

During baseflow conditions, dissolved and total organic carbon and metal concentrations in the rivers considered were comparable to values observed for other small coastal Mediterranean rivers, surpassing the world average river values. Concerning the trace metal dynamics in the plume salinity gradient (Fig. 1), Cu, Cd, Co, Pb and Zn are desorbed from the SPM, increasing the potentially bioavailable fraction of these metals. It was clearly demonstrated that the release of metal ions can occur at low salinity with fast kinetics followed by partial re-adsorption onto SPM; a behavior especially observed for Cu. Other metals (e.g. Ni) can undergo a fast adsorption onto SPM followed by slower desorption. Such unusual behaviors make mandatory the practice of filtration immediately after sampling to avoid under- or over-estimation of dissolved metal concentrations (Oursel et al., 2013).

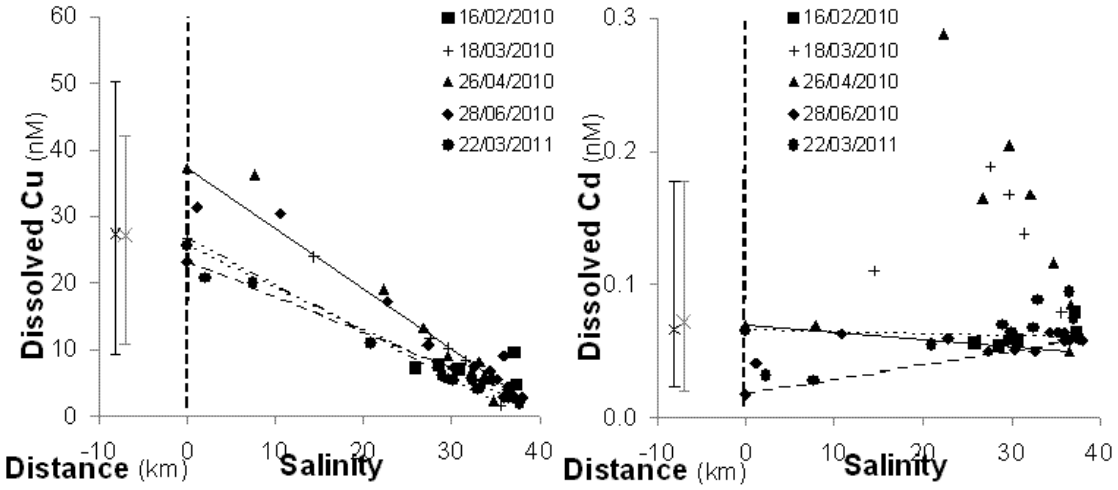

Figure 1. Variation of dissolved Cu (lSeft) and Cd (right) concentrations, during dry season, in rivers (as a function of the distance until the outlet) and from outlet to seawater (as a function of the salinity).

A second important point of this study is that, at the outlet, the river signatures were hidden by the WWTP anthropogenic input for most elements or compounds. The anthropogenic input was higher than 90% of the total input to the sea for particulate Cd, Pb and Cu and higher than 65% for particulate Zn, Co and dissolved Zn and Pb. The daily variation of these inputs followed the fluctuations of the TWW issued from WWTP. Although most likely not frequent, the observed abnormal event linked to a WWTP malfunction or bypass can temporally strongly enhance the impact of an urbanized area on the coastal zone. Similar phenomena all around the Mediterranean are more than probable, especially in countries without wastewater treatment plants. This underlines the need for such treatment facilities for an improvement of local coastal water quality, but most likely also at a more global scale. Such chronic fluxes of pollutants require better study in

comparison to other main sources (large rivers, aerosols, etc.). During wet conditions, trace metals fluxes increased, with a main contribution from rivers (compared to WWTP). Considering the high anthropogenic organic matter and trace element contents of the output to the sea, a detailed study of their chemical speciations, which are known to be strongly influenced by dissolved organic ligands, must be performed to evaluate their bioavailability for marine biota.

Surface sediments were also collected along a coastal-offshore transect (up to 800m from the outlet), and analyzed for major/minor/trace inorganic elements and organic pollutants (hydrocarbons, PAH, PCB) (Syakti et al., 2012). For most of the studied inorganic and organic contaminants, the obtained values significantly overpassed background levels and limits defined by the French authorities in the context of dredging, which attests the past and present contamination of this area and so the strong impact of such urban inputs.

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25.6

Mercury and Methylmercury resuspension in Vidy Bay, Lake Geneva (Switzerland)

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Mercury (Hg) is an element that accumulates in sediments. Hg can then be transformed into methylmercury (MeHg) by the activity of some bacteria. This form of Hg is known to bioaccumulate in organisms and bioamplifes along the food web. MeHg is highly toxic because it affects the nervous system of organisms.

Lake sediments in Vidy Bay (Lake Geneva) have been shown to be highly contaminated by Inorganic Mercury (IHg) and MeHg. This amount of Hg has been related to the effluent of a Waste Water Treatment Plant (WWTP) that releases into the bay treated wastewaters and combined sewer overflows, loaded with elevated content of organic matter and contaminants, making Vidy Bay rich in heterotrophic bacteria.

The aim of this study was to assess the sources and fate of Total Mercury (THg) and MeHg in the lake. The closest sampling sites to the WWTP reach 1.32 mg/kg of THg and 5.2 µg/kg of MeHg. Further away from the WWTP influence, THg and MeHg concentrations were 0.17 mg/kg and 0.56 µg/kg respectively. In parallel, settling particles have been collected by sediment traps during a one-year period at two sites and two depths. MeHg concentrations on settling particles varied between 1 and 16 µg/kg in the upper sediment trap locations (Figure 1).

As mentioned above, MeHg concentration can be five times higher on settling particles than in the surface sediments. In order to evaluate the hypothesis of an artificial methylation on settling particles during the one-month period collection, sediment traps were exposed to an antibiotic mixture to inhibit the growth of bacteria on the collected particles. MeHg was measured and DNA and RNA were extracted to assess bacterial community structure and functions. MeHg concentrations were lower on settling particles treated with antibiotics than on untreated ones. Therefore, an artefact resulting from a confined environment that promotes anoxia and development of a methylating bacteria community could explain the high MeHg observed in the sediment traps.

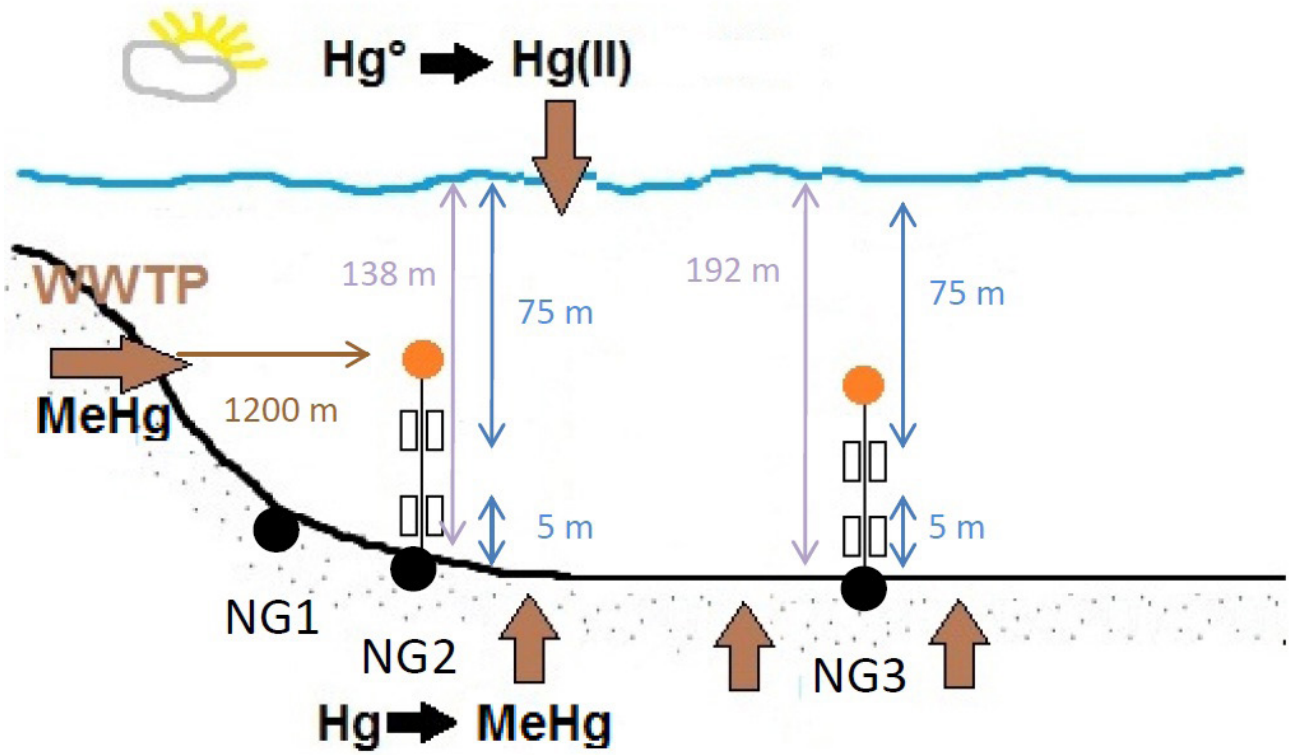

Figure 1. Diagram of the sediment traps catchment system into the lake.

25.7

Radionuclide fluxes in Lake Biel sediments (1955-2010) and Mühleberg NPP ^{137}Cs liquid emissions

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Lake sediments are good archives of changes happening in their upstream river catchment and environment. Since the second half of the 20th century, they record the history of artificial radionuclides emissions deriving from human activities. ^{137}Cs emissions started in the early 1950's and peaked in 1963-64 due to high atmosphere nuclear bomb tests. A second activity peak, due to the Chernobyl accident in 1986, can also be detected in central Europe. These two events serve routinely as time markers for recent lake records.

Lake Biel, a mid-sized lake of the Swiss Plateau, lies on the Aare river course and serves as drinking water reservoir for the town of Biel (60'000 inhab.). Its outflowing water is further used by downstream cities lying on the Aare-Rhine course such as Basel (200'000 inhab.). In Switzerland, Nuclear Power Plants (NPPs) were constructed along the Aare river course for cooling purposes. Since 1972, Mühleberg NPP lies 18 km upstream Lake Biel and releases radioactive liquid emissions into the Aare which adds to the diffuse - above mentioned – radioactive pollution, as revealed by Albrecht et al. (1995; 1998) from Lake Biel sediments and recently confirmed by Thevenon et al. (2013).

In this study, the ^{137}Cs activity curve of a 90-cm-long sediment core (BIE10-8), retrieved in April 2010 from the central Lake Biel basin at ca. 50 m depth, and measured by gamma ray spectrometry using high resolution germanium detectors, confirms previous work and reveals a new peak for the year 1998-2000, as observed by Thevenon et al. (2013). This peak is most certainly due to Mühleberg NPP as shown by the good correlation with declared ^{137}Cs liquid emissions indicating a significant increase in 1998-99. Comparison with previous data confirms that the central part of Lake Biel, being in the main pathway of Aare underwater inflow, shows a clearer recording of the ^{137}Cs river input than other sites (Albrecht et al. 1999). Decay corrected activity data, converted into ^{137}Cs fluxes, point to water pollution by Mühleberg NPP in 1975-1985 as being similar to those linked to the catastrophic events in 1963-64 and 1986 (about 75%). As Lake Biel sediments scavenge only a portion of the total radionuclide in water (30-55%; Albrecht et al. 1999), the present results raise concerns on the past radioactivity of water along the Aare and Rhine course, as the non-scavenged radionuclide emissions add-up in the same river system until Basel (and beyond in Germany). Out of the scope of this work, questions arise on the effects of >35-years-long exposure to low but repeated radioactivity in drinking water over human health and aquatic environments.

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25.8

Assessing the risk of mixture of micropollutants in Geneva lake: from the theoretical approach to "in-situ" ecological effects.

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Geneva lake is essential as ecosystem, but it is also used as recreational area, for fishing, and as source of drinking water for more than 600'000 inhabitants. The control of the lake water quality is therefore crucial and a long-term survey is organised by the Commission pour la protection des eaux du Léman (CIPEL, www.cipel.org). This survey provides data on the broad range of chemicals detected at the middle of the lake and in catchment for several years. However, the environmental risk posed by these chemicals is still often assessed substance-by-substance, neglecting mixture effects. In this poster, we present the strategy we used to assess the risk of these chemicals as a "cocktail". The approach is based on two models called "concentration addition" and "response addition". The environmental risk assessment of mixture has to deal with the lack of ecological toxicity data for several compounds, which leads to use simplified methodologies and mathematical extrapolations. Indeed, the above models are usually used to calculate a prediction of affected species according to a simplified mathematical methodology but that has the advantage to overcome the lack of data. Therefore, in a first step, our study aimed in validating the use of this mathematical methodology for risk assessment by comparing predictions with a more stringent procedure. Ours results confirmed the validity of this methodology but showed that great uncertainties appeared above some mathematical limits. Then, we assessed the risk of the herbicides detected in Geneva lake for several years and estimated their potential impact on phytoplankton community. The results highlighted a correlation between some algae species and the calculated mixture effect gradient, taking into account the other potential stressors, i.e. the physic-chemical changes. The potential influence of herbicide mixture on some specific populations of micro-algae species is a first step in the understanding of the impact of herbicides on ecological functions of the ecosystem of Geneva lake.

25.9

Current variability in a wide lacustrine embayment (Vidy Bay, Switzerland)

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Field measurements and numerical simulations were carried out to examine the effects of meteorological conditions on the hydrodynamics in Vidy Bay. To simulate the flow field, a 3D finite difference hydrodynamic model (Delft3D-FLOW) was employed that simulate whole of Lake Geneva. The Lake hydrodynamics were computed using the Navier-Stokes equations combined with a k-ε turbulence closure model. High-resolution bathymetry and a non-uniform grid system were applied. Detailed over-lake maps of wind, temperature and humidity were used as input to drive the model. An accompanying Lagrangian experiment, using drifters, was conducted in the bay to capture the current patterns and local meteorological data. Acoustic Doppler Current Profiler (ADCP) data and Lagrangian drifter studies in Vidy Bay were compared with numerical results and a reasonable agreement was achieved. Meteorological conditions were categorized in a limited set of typical events and then several numerical scenarios based on typical conditions were simulated. Markedly different circulation patterns were measured within the embayment, with the transition from one pattern to another occurring abruptly for small changes in wind direction. These distinct patterns resulted from relatively small changes in the large gyre of Lake Geneva's main basin, especially the angle between the current in front of the embayment and the embayment shoreline. The model is able to reproduce the velocity profiles and the temperature structures during events.

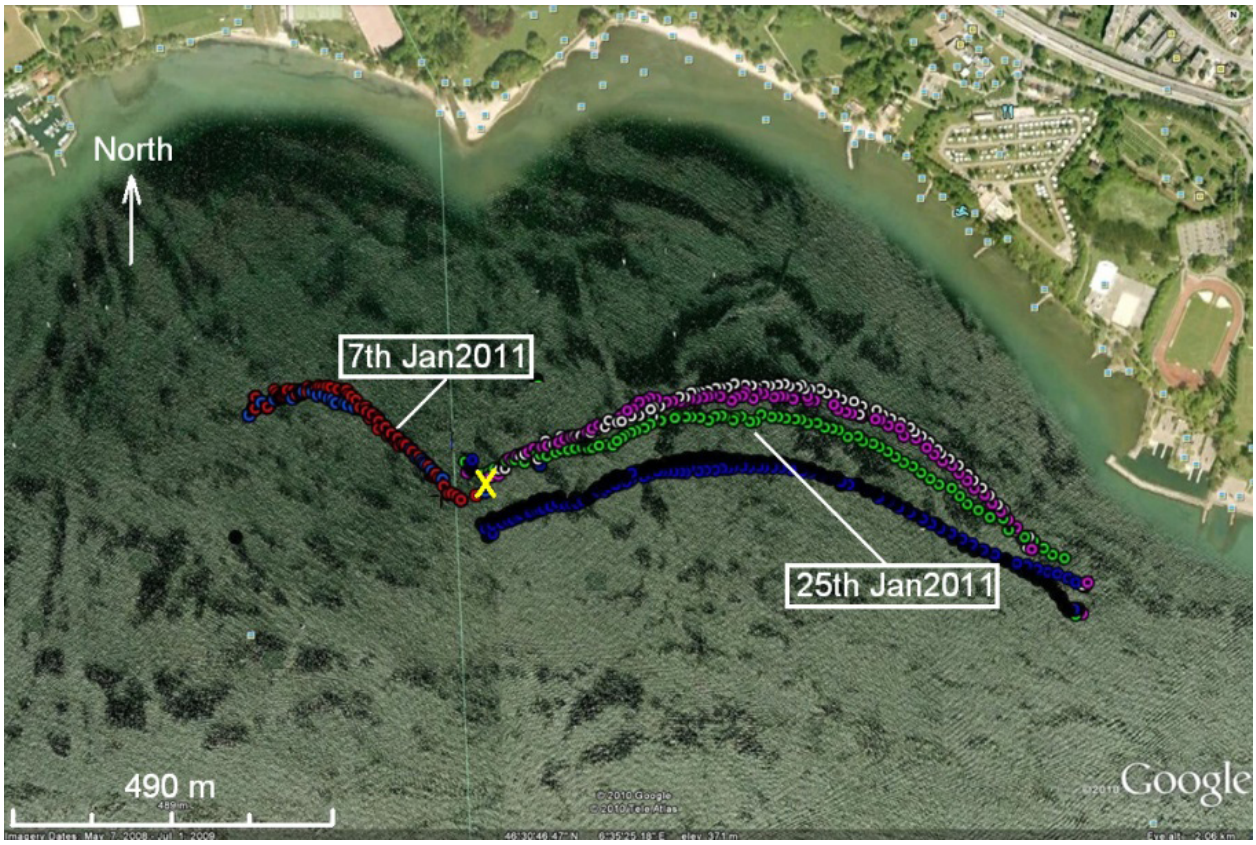

Figure 1. Drifter studies in Vidy Bay (Lake Geneva) showing that there are different current patterns after the similar wind event (Bise) in the embayment.

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25.10

Trends in organic carbon concentrations in Swiss lakes

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It is generally accepted that organic carbon (OC) concentrations have increased in rivers and lakes of Northern Europe and North America over the last 20-30 years but numerous exceptions to this trend exist. As part of our on-going study on long-term OC dynamics in freshwaters (Rodríguez-Murillo et al. 2013), we have studied OC concentration trends in 34 lakes in Switzerland using data from the Swiss Federal Office for the Environment (FOEN). The set of lakes studied includes large Swiss lakes (7 lakes, 9 times series) as well as 27 smaller lakes (30 time series). All OC concentration time series are longer than 10 years and include at least one value per year (sampling frequency from 1 to 26 per year). Time trends have been studied with LOWESS (LOcally, WEighted Scatterplot Smoothing) regression; long term trends have been obtained with the non-parametric Mann-Kendall and Seasonal Kendall methods. There is no common temporal trend in the OC of the Swiss lakes studied. Large lakes generally show a small (<1% mean OC concentration per year) increase in OC concentrations (increase in 6 series, of which in 4 significantly, and decreases in 3 but none significantly. Small and medium-sized lakes display different trends and levels of significance. These results will be presented together with the discussion of the weight of allochthonous OC versus primary production in the trends observed as well as of the relationship between OC concentration trends in Swiss lakes and rivers.

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25.11

Diffuse sources of micropollutants in a mid-size-lake: how to handle them?

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Diffuse sources of micropollutants in Lake Geneva are regularly identified through monitoring and research activities, including the LEMAN21 (www.leman21.ch) project. However, several questions remain open regarding the origin of the pollution, its importance and how to handle it. These micropollutants may represent a risk for the ecosystem of Lake Geneva and for the population around the lake, through drinking water. The goals of this study are:

- to identify and quantify diffuse sources of micropollutants in Lake Geneva through sampling and analysis of three tributaries of the lake
- to develop a methodological approach for the sampling of diffuse sources of micropollutants;
- to propose a conceptual approach for the diffuse inputs into Lake Geneva

To reach this goal, three watersheds were equipped with flow measurement systems and auto-samplers to measure the concentrations of 19 substances during rain events and dry weather periods. They are the Rhône watershed (Porte-du-Scex) Chamberonne and Venoge [Rossi and Chesaux, 2013]. On the Rhône river, three sampling campaigns of 14 days (daily samples) were conducted. Three average 14 days samples were also analyzed following the screening methodology developed by Eawag on the Rhine River [Krauss et al 2010]. The results show relatively low concentrations in the Rhone, with the presence of some industrial substances. The concentration ranges are similar to those measured in the Rhine. The screening methodology allowed identifying a molecule not commonly measured in the Rhone River.

The results obtained in rivers Chamberonne and Venoge are representative of the tributaries of Lake Geneva in terms of pesticide concentrations. The results of our measurements show relatively low concentrations during dry weather period and high pollutant dynamic during rain weather period, leading to concentrations sometimes exceeding standards environmental quality standards (EQS).

For each watershed, the quantities of substances used in agriculture were estimated on the basis of the PESTIBASE tool developed by CIPEL [Klein et al 2007]. For the Rhone basin, the comparison between the theoretical quantities applied and the measured concentrations is satisfactory. A detailed survey of part of the Chamberonne watershed was also performed. The study of the reliability of the results was performed using tools based on the sampling theory [Rossi et al, 2010]. For the Rhone, the uncertainties on the annual mass discharged to Lake Geneva are estimated at 35% for dissolved compounds. For the adsorbed compounds, a change in the sampling procedure is needed to reduce the level of uncertainties. In the case of other rivers, taking average samples over 24 hours during the year cannot estimate the annual load in a satisfying way (uncertainty of about 60% even with 40 samples per year). The study of sampling scenarios is strongly recommended before embarking monitoring programs. The establishment of a guideline or a directive on diffuse pollutant sampling is also highly recommended.

A concept leading to the development of indicators of diffuse pollution from agricultural sources for the classification of watersheds is also proposed, based on the agricultural activities and on the watershed vulnerability. A test was conducted on Chamberonne and Venoge watersheds, demonstrating the feasibility of this approach using the tools and the data available in the Geneva Lake context. The criteria and the assigned weights to the different selected indicators still need to be discussed by an expert group.

As a conclusion, we find that the measurement of micropollutants in different rivers is now considered as a goal in itself. But the real goal is to supply information for management tools dedicated to the preservation of the natural environment. These tools are, at present, lacking. Better planning of measurement campaigns based on specific goals and scenarios defined thanks to these tools is essential to avoid accumulating little or no representative information.
Prioritization of watersheds, in terms of diffuse pollution contamination and risk is a need to better target actions to preserve the environment of Lake Geneva

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P 25.1

Chronic tests of two anticancer drug metabolites on Daphnia pulex

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Pharmaceuticals taken by humans are eliminated through the excreta in either intact or transformed form (i.e. metabolites). In developed countries, drug residues follow urban sewage water networks to a sewage treatment plant (STP), which has originally been intended for organic matters, but not such chemicals. Therefore, pharmaceuticals and derivatives that still have some pharmacological activities may escape STP processes and reach the aquatic ecosystem (Williams, 2005). Such bioactive molecules are susceptible to interact with biological processes of aquatic species, even at low concentrations.

Among other pharmaceuticals, anticancer agents are of particular concern because of their potential side effects on human body (Daughton and Ternes, 1999). Tamoxifen is a chemotherapeutic anti-estrogen compound that is prescribed worldwide for the prevention and treatment of hormone receptor-positive breast cancer. It is known to escape degradation process by STPs and was measured in both STPS effluents and natural waters at concentrations up to 0.31.8 µg/L and 0.22 µg/L respectively (López-Serna et al., 2012). In a previous study (manuscript in progress), we showed that tamoxifen induces neonatal abnormalities in *Daphnia pulex*, a freshwater microcrustacean, exposed over 21-days to concentrations ranging from 0.2 to 1 µg/L.

Tamoxifen is considered nearly as a prodrug (Rautio et al., 2008), which release active molecules after enzymatic and/or chemical transformation *in vivo*. Although tamoxifen is already an active molecule, two of its metabolites namely 4-hydroxy-tamoxifen (4OHTam) and endoxifen are pharmacologically more potent in vertebrates. These metabolites as well as their parent compound are body-excreted, mainly through feces. Tamoxifen and both metabolites continuously reaching the aquatic environment may induce long-term effects on aquatic organisms. However, to the best of our knowledge, no data have been reported addressing actual concentration of endoxifen and 4OHTam in the aquatic environment and their long-term effects on aquatic organisms. In this work, we assessed the long-term effects of 4OHTam and endoxifen on *D. pulex* over two generations (F0 and F1). The objective was to observe whether these anticancer drug metabolites affect the survival, reproduction and size of daphnids.

The results showed that the metabolites 4OHTam and endoxifen induced effects on reproduction, survival and body-length at relatively low concentrations. The mortality was 100% in the F0 generations exposed to 99 µg/L of 4OHTam or 202 µg/L of endoxifen. The reproduction decreased significantly in the F0 and F1 exposed to 6.8 and 23.8 µg/L of 4OHTam. In addition to mortality and disturbed reproduction, differences of body-length were observed. At the two highest concentrations tested, the F0 generation did not grow up and kept a size similar to control < 24-h neonates. The offspring from reduced-size parents were also smaller at the end of their respective test period.

In spite of their high pharmacological potency and their extensive release in the environment, endoxifen and 4OHTam had never been tested on aquatic species. While we could show detrimental effects of these tamoxifen metabolites on *D. pulex*, additional long-duration experiments should be carried out on daphnids and other aquatic species to confirm the results and better characterize their effects on the aquatic fauna. In general, pharmaceutical metabolites are insufficiently studied in ecotoxicology and the question of prodrugs and active derivatives receives too little consideration in this field. The issue of active metabolites should be fully integrated into the environmental toxicology assessment of pharmaceuticals, as currently required by the European Medicine Agency. We hope that our observations contribute to promote a better integrated assessment of pharmaceutical ecotoxicity of both novel and ancient medicines.

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P 25.2

Physical process and hypoxia in Lake Erie

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Hypoxia in the hypolimnion of Lake Erie has been examined by assessing (i) the spatial and temporal extent of the hypoxia (e.g., July to October in the central basin, $>10^4$ km^2) and (ii) linking the rate of oxygen (DO) depletion to the hypolimnion thickness. However, assessing the processes driving inter-annual variability in oxygen and the small-scale temporal and spatial patchiness in DO depletion (-0.7 to +0.3 mg L^{-1} d^{-1}) remain unknown. Data from the summers of 2008 and 2009 in central Lake Erie (13 moorings) enabled us to quantify how much of the DO variability is controlled by physical processes, relative to biological processes and the sediment oxygen demand (SOD). The flux of oxygen through the thermocline to the hypolimnion was equivalent to ~18% of the total oxygen depletion in the hypolimnion over the stratified period. The total oxygen depletion in the hypolimnion was due to equivalent amounts of *HOD* and *SOD*. This latter finding was strongly dependent on hypolimnion thickness, which appears to control the vertical volumetric fluxes and hence the competition between vertical flux and community respiration in the hypolimnion of other shallow lakes.

P 25.3

Spatial runoff estimations based on the deuterium-excess due to the isotopic evaporation effect in an upstream lake

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Where does the water in a stream come from? We asked this question for the stream *Reppisch* close to Zürich. With a growing urbanisation and possible changes in the water regime there is an increasing need to obtain better information about the *Reppisch*-catchment (25 km^2). As a tracer we used the stable water-isotopes $\delta^{18}O$ and δD, which are a proven tool to understand the different flow paths of water and help to quantify the groundwater contributions along the *Reppisch*. The *Türlersee* at the top of the long narrow *Reppisch*-valley and the absence of bigger inflows to the stream make this an ideal location for examining the contribution of a lake to downstream discharge by tracing the isotopic evaporation signal of the lake. We compared isotopic and hydrometric data of the summers 2010, 2011 and 2013 for the *Türlersee* with that at different locations downstream along the *Reppisch* and at some inflows as well as that of precipitation in the area. First results show that the isotopic evaporation signal of the *Türlersee* is clearly traceable downstream the *Reppisch*. The deuterium-excess curve of the *Reppisch* approaches closer to the Global Meteoric Waterline (GMWL) the further the distance from the lake. We conclude that this alteration occurs mainly through groundwater and the small inflows from the hills aside the *Reppisch.* The inflows' deuterium-excess signal is lying in the range of 7.5 to 10 $\%_0$. This is up to 8 $\%_0$ closer to the GMWL than the *Türlersees* and *Reppischs* signals. We reason that the further away from the lake the bigger becomes the portion of the little streams and groundwater in the *Reppischs* discharges. In the case of an event, the immediate reaction of the little streams and their isotopic signal being close to the isotopic signal of the current rain, show that the dynamics of the *Reppisch*-system leads the precipitation to a quick runoff. The obtained results can serve as a basis for an improved hydrological model of the *Reppisch*-catchment by allowing calibration and testing of spatially distributed simulations.

P 25.4

Enhancement of the representativeness of herbicide effect modelling in watercourses.

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These last years, many herbicides were detected in Swiss watercourses. The concentrations of some of these herbicides were higher than the criteria of 0.1 µg/l defined in the Swiss legislation. Moreover, these herbicides are discharged non-continuously in watercourses or streams after crop applications and during rain events. It is therefore important to determine the effects of these non-continuous exposures on aquatic species. Algae species are specifically interesting as they are commonly very sensitive to herbicides. Furthermore, they are at the base of the food chain. Consequently, if they are damaged, the whole fauna may be affected. In this context, a model was developed to assess the growth inhibition of the green alga *Scenedesmus vacuolatus* caused by non-continuous exposure scenarios to the herbicide isoproturon. The uncertainties of the predictions were also estimated. This model was validated with laboratory experiments. Non-continuous exposure is characterized by periods of exposure (with the herbicide) and recovery (without the herbicide). The effects on algae species will therefore depend on the length of these 2 types of periods but also on the herbicide concentration during the pulse exposure. Indeed, even if the pulse duration is short, a high concentration can inhibit the growth of the algae. To improve the environmental representativeness of this model, it was adapted to predict the effects of non-continuous exposure to mixture of herbicides. Finally, the model was also evaluated by testing pulse exposure scenario of isoproturon on two algae species growing in the same medium: a circular one (*Scenedesmus vacuolatus*) and a rangy one (*Pseudokirchneriella subcapitata*). The model validity is discussed for each case studied.

P 25.5

Calculation of Physical Chemistry Parameters (Amount and Rate of Salt Precipitation) from Brines Urmia Lake

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Urmia Lake as the largest hypersaline lake in the world located Azerbaijan area(NW of Iran). Considering the international importance of saving Urmia lake from the drying crisis and attention to the problem of thick masses of salt accumulation in the lake bottom,in the present study,we intend to show that how, where, and at what rate a hypersaline brine as a case the Urmia lake gets rid of one of its components, the common sodium chloride.

The actual density-salinity relation $\beta^*=\Delta\rho/\Delta S$ is a combination of two different thermodynamic constants. One of them, β_{NaCl}, is the brine's expansion coefficient to sodium chloride and relates to the process of halite precipitation; and the other β, is the brine's expansion coefficient to total salts and relates to the dilution-evaporatiqn process. For every particular period under study, the actual density-salinity relation β^* must be evaluated separately. The approximate salinity value and the observed rate of change of density and with estimations of salt balance of the lake, yield an evaluation of the rate of salt precipitation from the Urmia lake. The existing estimations for the salt balance of the lake are widely variable, reflecting the unknown subsurface water inflow, the rate of evaporation, and the rate of salt accumulation at the lake bottom. To estimate these we calculate the mass balances for the Urmia lake utilizing measured meteorological and hydrographical data from 1999 to 2011.

P 25.6

The History of Sedimentation and the Risk of Falling Urmia lake level in Iran

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Background and Aims: Urmia Lake is one of the biggest and salt over-saturated Lakes in the world. It is located at the northwestern part of Iran. Today, it has been endangered by drying up processes. This environmental hazard is one of the most significant geological problems of Iran. Verification of evolutionary history of Holocene and understanding the reasons for sudden downfall of Urmia Lake water level is the main subject for current study.

Objectives: In this research, remote sensing examinations for a period of 35 years, 55-year climatic data processing and their relationship with Lake Water fluctuations were implemented, and undisturbed sedimentary cores of western Lake sediments were prepared by Auger coring method(eg. Piovano et al., 2002).16 cores having a maximum depth of 9 meters, and totally 98m of the Lake sub-floor sediments were verified.

Methods: Sedimentary facies were separated by color, grain size, mineralogy specifications, sedimentary fabrics and evaporative minerals(Li et al., 1996: Valeo- Garces et al., 1999; Benison, K. C., and Goldstein, R. H., 2001). With regard to vertical sedimentary facies (from surface to sub-surface areas) changes, geography, climatic conditions and Lake water level fluctuation were re-constructed. Results indicated 17 separable types of sedimentary facies in cores. Facies are from Lacustrine, Playa, Swamp, fluvial and terrestrial environments. Coring and verification of Lake Sub-environment sedimentary facies indicate that sequential drying up tracks are visible in the coastal areas of Urmia Lake

Results: However, the main part of the Lake has had Lacustrine environment (6.5m of the Lake floor sediments) for 13000 years. Sedimentation was continuous during the mentioned period and seismic data confirm this issue. Climate change and particularly evaporation increment are significant agents in downfall of Lake water. But these are not the main causes for drought in Urmia Lake region. Iran has experienced a long-term drought since 13000 years ago up to now. Hence, shallow Lakes, such as Maharloo, Mirabad and Zarivar were frequently dried(Lak et al., 2007). It is important to note that Urmia Lake has never experienced dryness except in coastal areas. The main stage of Urmia Lake region drought commenced about 13000 years ago. This event indicated coincidence with the last Ice Age. Regarding the Ice Age, downfall of moisture and Lakes‘ water levels of North Africa and southern Asia was pointed out(Cohen, 2003).

Conclusions: Based on assessment of age in urumia lake sediments (Kelts and Shahrabi, 1986) sedimentation rate varies from 0.1 to 1 mm per year. But the core near the core study area sedimentation rate is about 0.5 mm per year The facies sequence of the great drought in the lake at a depth of 650 cm with an approximate age is 13,000 years since there is continuous deposition of supersaturated salt in a lake.But now not only at the core of the harvest, but up to 4 km of the lake has become a dandruff dry prairie and desert, which indicates the influence of anthropogenic factors (water structures such as dams, Bridge, indiscriminate use of water resources underground) present in the lake is drying. Therefore, today, the important agent in downfall of the Urmia Lake water is anthropogenic factor.

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P 25.7

Evolution of Lake Maharlou brine during 4 years monitoring

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Maharlou Lake is located southeast of Shiraz, Iran (Fig. 1). In wet seasons, the Lake in its largest size is 26 km long and 12 km wide covering an area of 280km^2. The Maharlou basin is situated in a relatively elevated depression (1455 m above sea level) with a northwest-southeast trend. Maharlou Lake is an intra-continental sedimentary basin. The water level in the lake is controlled by several factors, including runoff from Maharlou catchments, groundwater seepage, and direct rainfall over the lake and the evaporation rate. Hydrochemistry of the catchments water resources showed mainly chloride and sulfate waters due to the geology of the surrounding areas and its variable lithology. Hydrochemical investigations were carried out over a time period from 1975 to 2002 using previously published analysis, together with newly collected water samples. Two hundred thirty samples were collected during summer 2002, 2003, 2004 and spring 2005. The new types of waters flowing into the lake were also determined. Hydrochemical analyses of these waters showed that the difference of cations and anions is a cause for the different geological features (e.g Jones and Deocampo 2004). The amount of calcium and magnesium cations and sulfate and chloride anions are dominant. It should be noted that in all the input waters, the total amount of Ca and Mg exceeds the amount of HCO3; HCO3 << Ca + Mg. This means that evolution path II of the brine evolution flowchart (Eugster and Hardie 1978) eventually create a Na-SO_4-Cl or Ca-Na-Cl brine type, whereas the current brine is Na-Mg-Cl-(SO4) which belonged to the path III_{2b} of the mentioned flowchart. The current Maharlou Lake brine type is similar to Great Salt Lake in the USA (Spencer et al. 1985). Relative amounts of ions in dry and wet seasons are as follows: Na> Mg> K>Ca and Cl> SO_4>HCO_3> CO_3 (Fig. 7). Due to high concentrations of sodium and chloride, on the surface of the lake, salt crusts are developed during the dry season. In the wet season, dissolution of salt crusts increases lake water concentration. In the summer, large amounts of evaporite minerals precipitate to the lake floor (Sonnenfeld 1984). The largest amount of salty crust precipitated in the summer of 2002, when it reached a thickness of 60 cm. During wet seasons, diluted waters entering the lake dissolve a major portion or even the whole salty crust. Mineralogy composition of the salty crust, in the dry condition is only Halite whereas in wet conditions a variety of evaporite and carbonate minerals are precipitated; among which Halite, Gypsum and Calcite are the most abundant.

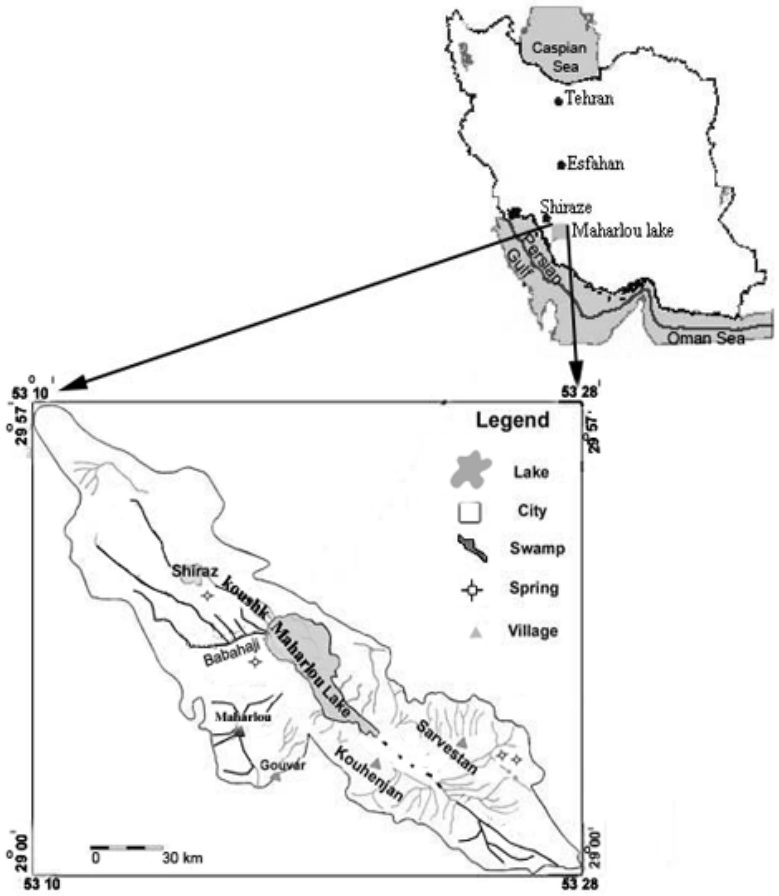

Figure 1. Hydrographic map of the Maharlou Basin. Nahr-e-Azam (Khoshk) and Chenar Rahdar Rivers are more important than others.

Results showed distinct changes in the brine type over time; from Mg-SO4-Cl type reported by Krinsley (1970) to a recent Na-Mg-Cl-(SO4) type, which is comparable with Great Salt Lake in the USA. A Change in diluted water composition going from HCO3 ≥ Ca + Mg to HCO3 << Ca + Mg has taken place. That is, the path of brine composition on the Eugster & Hardie (1978) flow diagram has changed from row III_{2b} to the path II, and may finally result in a Ca-Na-Cl or Na-SO4-Cl brine type in the future. In this study, two mixed zones of fresh and saline waters were recognized in the northwest and center of the lake, with the lowest ionic concentrations, located where there is significant river and ground water supply.

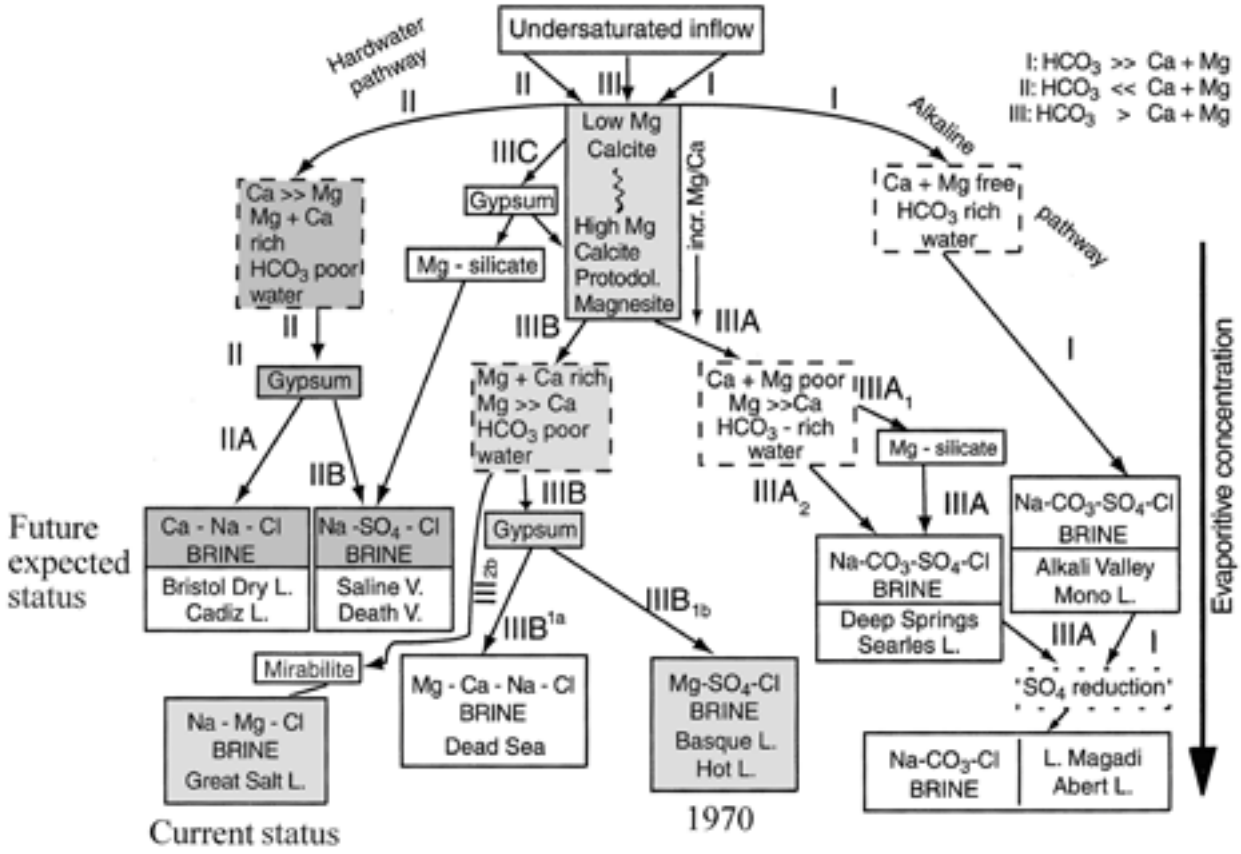

Fig. 2: Flow diagram for the geochemical evolution of closed basin brines from Eugster and Hardie (1978). The brine type changed from Mg-SO4-Cl type reported in 1970 to a recent Na-Mg-Cl-(SO4) type (highlighted in light gray).

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P 25.8

Sedimentology, Sedimentary Sub-environments and Mineralogy of Holocene Sediments of Maharlou Lake, Southwest of Iran

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Maharlou Lake with 280km2 catchment area in wet seasons is located southeast of Shiraz, Iran (Fig. 1) and according to the Sonnenfeld classification Scheme (1991), is regarded as an intra-continental basin. This research was conducted with the aim to determine sedimentary facies and identify evaporate minerals as well as the change in the type of mineral composition within the sediments that were formed during the Holocene period reflecting the balance in water input and output in the studied basin. In this study, thirteen core samples (max length 180 cm) were selected from the intact bottom of the Lake using a gravity core sampler (Mudroch and MacKnight, 1994). The core samples were then dissected in halves longitudinally, underneath the sediments, Playa environment was detected. In total, 85 sub-samples were prepared from various core samples of sedimentary facies, which were then analyzed using grain and mineral analytical methods such as granulometry and XRD (Fig. 2). In addition, details of sediment samples were examined with binocular and electronic microscopes. The results of these analysis showed that the Lake sediments are composed of three types of sediments: Detrital sediments, Carbonated sediments (chemical and biochemical sources), and evaporate sediments. Minerals that formed detrital sediments were: quartz, feldspar, clay minerals such as illite, palygorskite, flugopite. Carbonated minerals were calcite, dolomite, aragonite, magnesite, natron. Biochemical sediments were composed of artemia pallet dominated by aragonite. Evaporate minerals were gypsum, halite, basanite, polyhalite, glauberite, sudoite. The bottom of the Lake was mainly formed by sandy clay silt. A few gravel was found in some of the samples which originate from larger gypsum crystals.

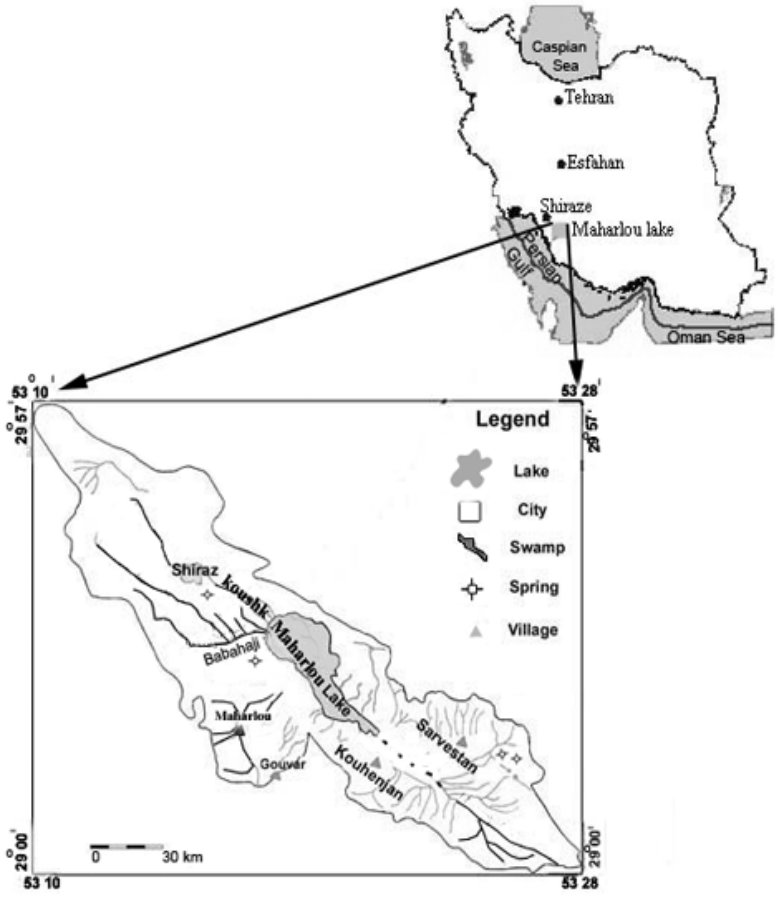

Figure 1. Hydrographic map of the Maharlou Basin. Nahr-e-Azam (Khoshk) and Chenar Rahdar Rivers are more important than others.

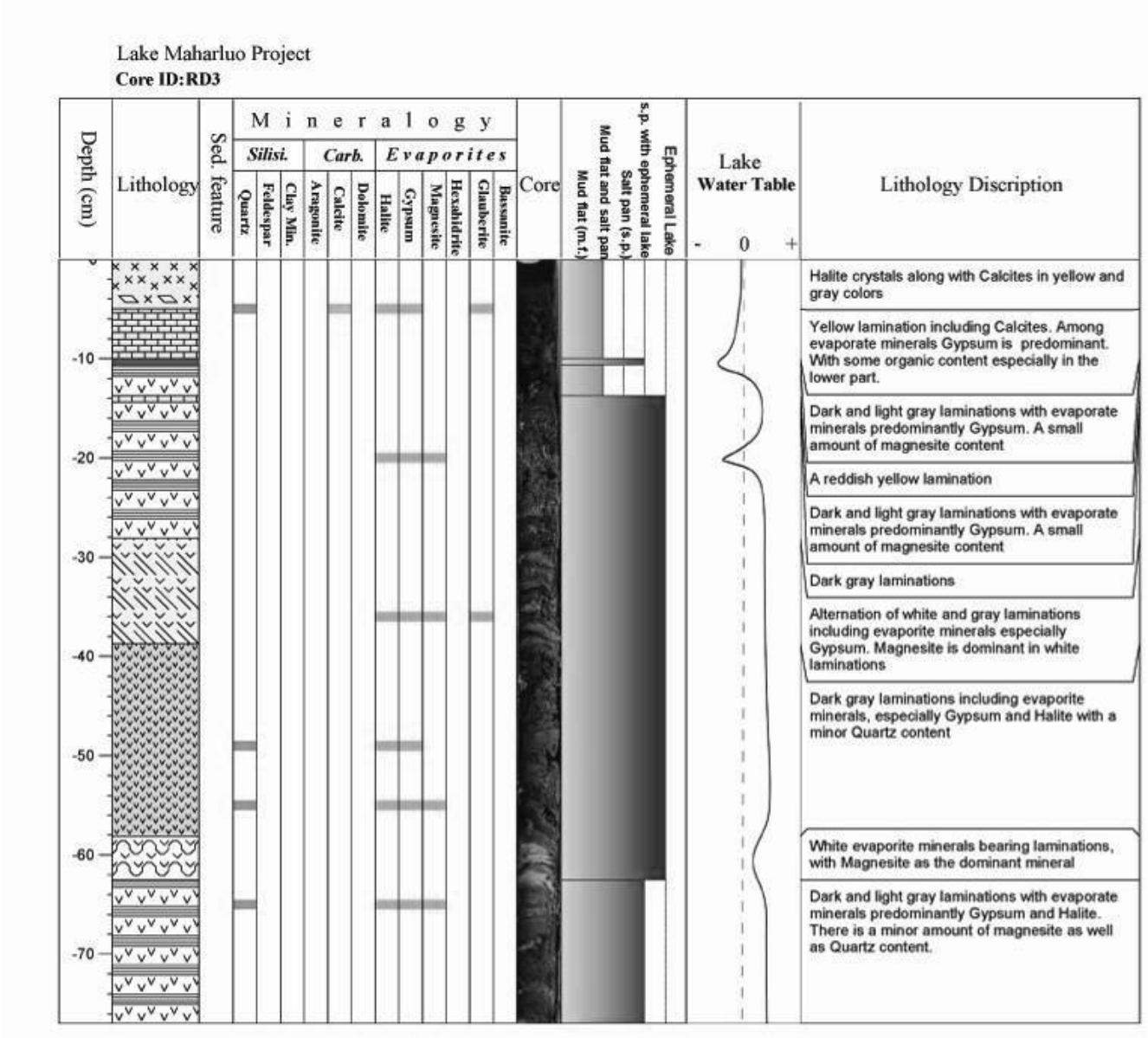

Figure 2. Description of stratigraphical, mineralogical, macroscopic image, sedimentary sub-environment, water table fluctuation column of RD3 core.

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P 25.9

Treatment of micropollutants in municipal wastewater: Ozone or powdered activated carbon?

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Many organic micropollutants present in wastewater, such as pharmaceuticals and pesticides, are poorly removed in conventional wastewater treatment plants (WWTPs). To reduce the release of these substances into the aquatic environment, advanced wastewater treatments are necessary. In this context, two large-scale pilot advanced treatments were tested in parallel over more than one year at the municipal WWTP of Lausanne, Switzerland. The treatments were: i) oxidation by ozone followed by sand filtration (SF) and ii) powdered activated carbon (PAC) adsorption followed by either ultrafiltration (UF) or sand filtration. More than 70 potentially problematic substances (pharmaceuticals, pesticides, endocrine disruptors, drugs metabolites and other common chemicals) were regularly measured at different stages of treatment.

Additionally, several ecotoxicological tests such as the yeast estrogen screen, a combined algae bioassay and a fish early life stage test were performed to evaluate effluent toxicity. Both treatments significantly improved the effluent quality. Micropollutants were removed on average over 80% compared with raw wastewater, with an average ozone dose of 5.7 mg O3 l-1 or a PAC dose between 10 and 20 mg l-1 (Figure 1). Depending on the chemical properties of the substances (presence of electron-rich moieties, charge and hydrophobicity), either ozone or PAC performed better. Both advanced treatments led to a clear reduction in toxicity of the effluents, with PAC-UF performing slightly better overall. As both treatments had, on average, relatively similar efficiency, further criteria relevant to their implementation were considered, including local constraints (e.g., safety, sludge disposal, disinfection), operational feasibility and cost. For sensitive receiving waters (drinking water resources or recreational waters), the PAC-UF treatment, despite its current higher cost, was considered to be the most suitable option, enabling good removal of most micropollutants and macropollutants without forming problematic by-products, the strongest decrease in toxicity and a total disinfection of the effluent.

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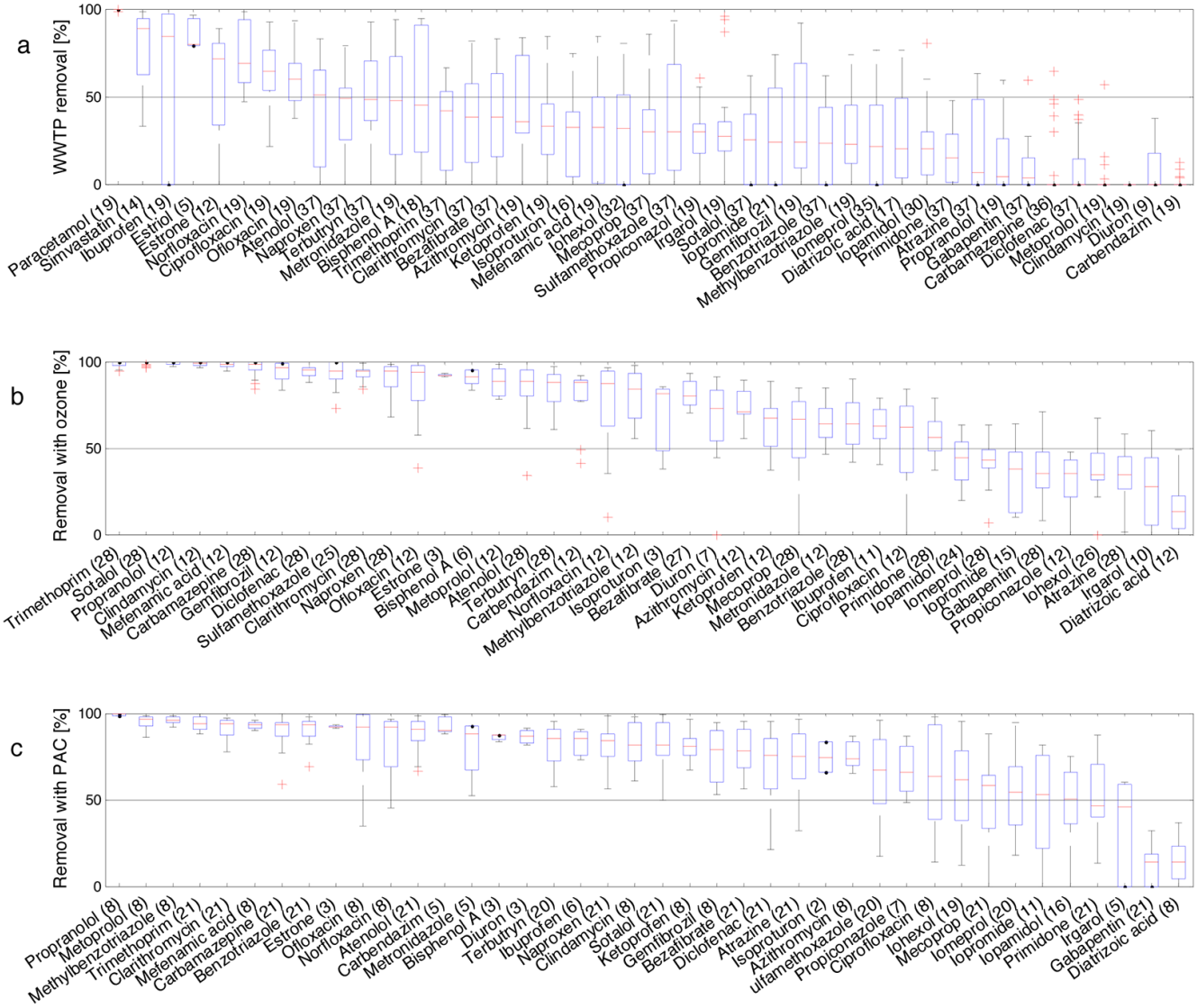

Figure 1. Removal efficiency of 40 to 43 micropollutants during (a) the conventional biological wastewater treatment with partial to complete nitrification (average removal of 35%), (b) the ozonation (ozone dose between 2.3 to 9.1 mg O3 l-1, median 5.9 mg O3 l-1 or 0.83 g O3 g-1 DOC, average removal of 71%) and (c) the PAC-UF treatment (PAC dose between 10 to 20 mg PAC l-1, median 12 mg l-1, average removal of 73%). Results of (n) analyses (24 h to 72 h composite samples) conducted between June 2009 and October 2010. Representation of the median removal, the quartiles 25-75 %, the minimum and maximum values and the outliers (after Margot et al., 2013).

P 25.10

Economical comparison of three water treatment projects in Vidy Bay (Geneva Lake, CH)

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Wastewater Treatment Plants (WWTP) as we know them nowadays were developed in the middle of the past century. Their first objective was to treat organic materials, nitrogen and phosphorus (Lofrano and Brown 2010). Recent progresses in analytical chemistry (High-Performance Liquid Chromatography, Mass spectrometry, Pressurized Liquid Extraction) have allowed pushing further the detection limit for pollutants into water, sludge and soils. As a consequence, many scientific studies of field measurement have reported the occurrence of non expected traces of new micropollutants in the environment, that widen the already long list of chemical substances present in open waters (Zoppou 2001; Verlicchi, Al Aukidy et al. 2012).

In Europe and in the USA, environmental agencies are increasing the pressure on water quality of wastewater treatment plants. Advanced treatment techniques such as ozonation will soon be required for the biggest of them, to prevent from the occurrence of human xenobiotics into the natural environment (OFEV 2009). As a result, water quality of WWTP effluents will get closer to World Health Organization standards for drinkable water (WHO 2008). This fact raises the social and economical question of direct water reuse (DPR) i.e., the transformation of raw wastewater into drinkable water. A better assessment of wastewater pollution dynamics at high time resolution, will help in the optimization of removal strategies and reduce the costs of DPR (Coutu, Wyrsch et al. 2013). The economical benefit of DPR is of major importance, as it could be the next source of water for countries suffering from water scarcity.

The objective of this study was to investigate the potential benefits of advanced water treatment techniques, including DPR, for the city of Lausanne, Switzerland. In this perspective, we compared different water treatment chains for wastewater and potable water. Comparison was made in terms of environmental performances and economical viability. The different treatment chain investigated are: (i) addition of ozonation at the end of the local (Vidy) WWTP (Micripoll 1), (ii) ozonation at the end of the local WWTP plus addition of powdered activated carbon to the potable water treatment chain process (Micropoll 2) and (iii), DPR i.e., the use of treated wastewater directly as input to the potable water network.

The results show that the use of DPR would lead to a significant increase of water price in the Lausanne area for a non significant water quality increase (Table 1). Thus, the application of this technique in a region not suffering from water scarcity is not recommended. Yet, the improvement of the water treatment process with techniques allowing micropollutants removal, for both wastewater and potable water chains (Micropoll 2), are advised to match future environmental regulations.

	New project supplementary cost (CHF/Year)	Consumer cost augmentation (%)
Micropoll 1	4.41E+06	12
Micropoll 2	9.74E+06	27
DPR	2.18E+07	60

Table 1. Supplementary costs to implement each of the three projects considered.

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P 25.11

Herbicides export dynamics of a mid-sized lake tributary: lessons from observations and modelling

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We present here a model which couples the hydrologic component and the transport of herbicides within a catchment. The model used takes into account the age structure of the stream water in order to characterize short and long term fluctuations of herbicide flux concentrations. The highly dynamic behavior of herbicides concentrations may lead to the exceedance of specific toxic threshold and is therefore key to exposure risk assessment of aquatic ecosystems.

The model is based on a travel time formulation of transport embedding a source zone that describes near surface dynamics. Travel time distributions are analytically derived for the case of solutes subject to partial intake from vegetation and chemical degradation. The framework developed is evaluated by comparing modeled hydrographs and atrazine chemographs with those measured in the Aabach agricultural catchment (Switzerland). The model proves reliable at representing the specific transport features shaped by the interplay of long term processes (persistence of solute compounds in soils), short and long term hydrological transport related to the temporal structure of rainfall. It also allows evaluating the effects of the stochasticity of rainfall patterns and application dates on the export dynamics of herbicides.

This exercise is further confronted to recent data obtained during three spring storm events in a tributary of Lac Léman. Nineteen herbicide compounds were analyzed at four sampling stations dispatched along the stream network. The occurrence of the substances, their specific release dynamics during storms are further discussed in regards to the atrazine data in the Aabach catchment and the model capability.

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P 25.12

Verification of Holocene Sediments in Hoz-e-Soltan Lake (Qom) through Sedimentary Cores

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Hoz-e-Soltan Lake is an ephemeral saline lake and according to the Sonnenfeld classification Scheme (1991), is regarded as an intra-continental basin. The studied Lake having 195km2 catchment area, 25-50cm depth, located at 85 km of southwest of Tehran, in Central Part of Iran (Fig. 1). It is located between 43°56‘ and 35°31‘ north and 50°53‘ and 51°20‘ east at western-north of Hoz-e-Masileh (Fayazi 1991). The maximum superficial relief is about 1940m to the north and 1150m to the south. On the basis of, Aqanabati classification (2006), the study area is located in Central Part of Iran. The objective of this research was to determine the paleoclimate and former water table fluctuations in Holocene through sedimentary facies studies. In this research, 9 cores were taken having a maximum length of 700 centimeters from the Lake substrate, and then facies investigations, such as sediment´s characteristics, organic matter contents, colors, crystals of evaporative minerals and sedimentary sub-environment were determined. 213 subsamples were prepared from different sedimentary facies, and then granulometry analysis and mineralogy XRD were carried out. Results indicated that there are 5 sedimentary sub-environments, including sand flat, mud flat, saline mud flat, salt pan and ephemeral lake in the 9 studied cores (Fig. 2). On the basis of granulometry results, 5 sedimentary types were recognized in the subsurface sediments which are as follows; slight gravel-bearing sandy mud, slight gravel-bearing muddy sand, mud, sandy mud and muddy sand.

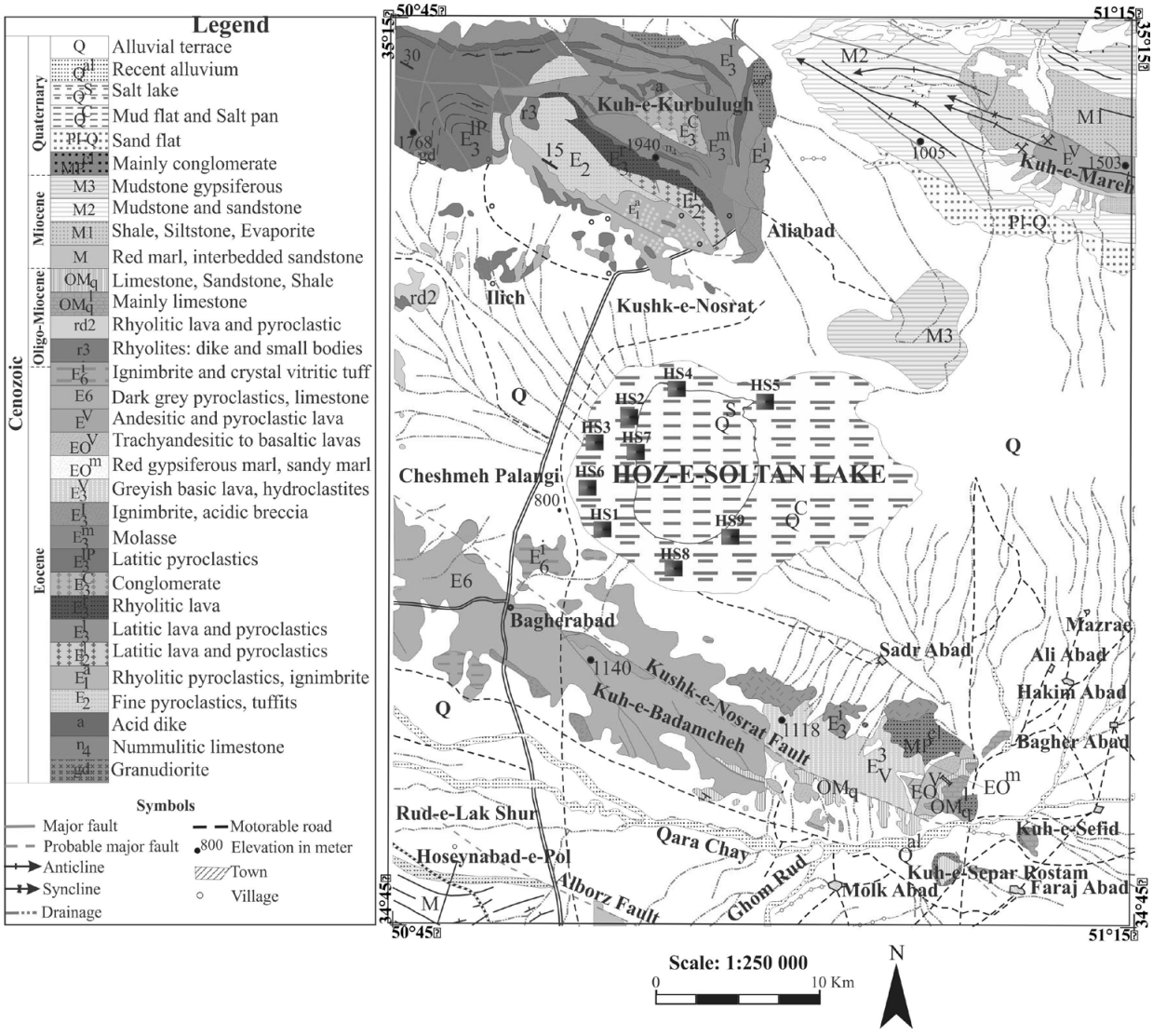

Figure 1. Geological map of Hoz-e-Soltan Lake (after Qalamqash, 2000).

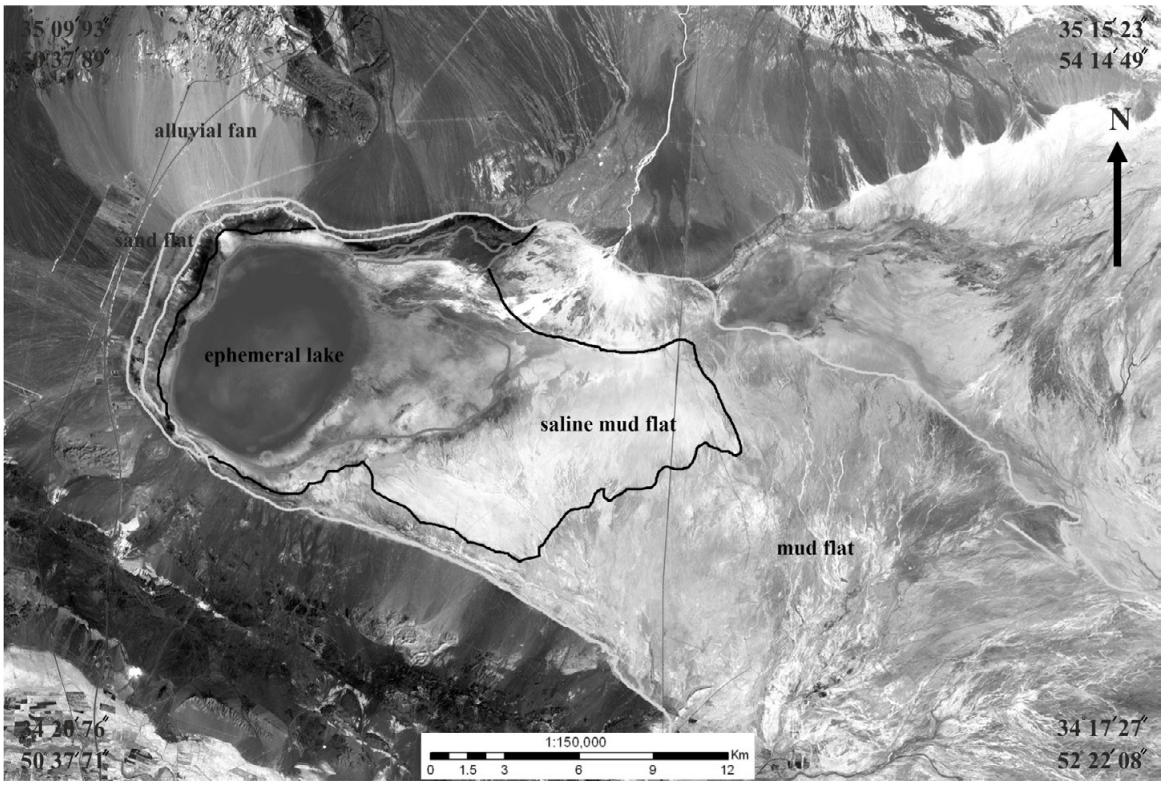

Figure 2. Sub-environments of Hoz-e-Soltan Lake

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