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A Sustainable Approach for Monitoring Metal Pollution at Watersheds

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Water is the most abundant molecule on Earth:

71% of Earth's surface is covered with water

- 97.5% of the global water is saltwater.
- 2.5% of the global water is freshwater.
- 884 million people do not have access to safe drinking water.
- 2.6 billion people do not have access to basic sanitation.

Safe water is scarce on Earth

United Nations - Water for Life (2005-2015)

- Millenium Development Goal No. 7:

Ensure Environmental Sustainability

Targets:

1. Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources
2. Reduce biodiversity loss by 2010
3. Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation
4. Achieve, by 2020, a significant improvement in the lives of at least 100 million slum dwellers

Unfortunately,

- In developing regions 50% the population of still does not have basic sanitation.
- The target on access to basic sanitation will be missed.
- In 2008, an estimated 2.6 billion people around the world lacked access to improved sanitation.
- If the trend continues, that number will grow to 2.7 billion by 2015.
- Especially sub-Saharan Africa and South Asia are the regions with drastic water problems with 69% and 64% of their populations still lack access, respectively.

Unfortunately,

- The 2010 target to slow the decline in biodiversity was missed.
- Nearly 17,000 species of plants and animals are currently at risk of extinction.
- Despite increased investment, the main causes of biodiversity loss
  - high rates of consumption,
  - habitat loss,
  - invasive species,
  - pollution and
  - climate change

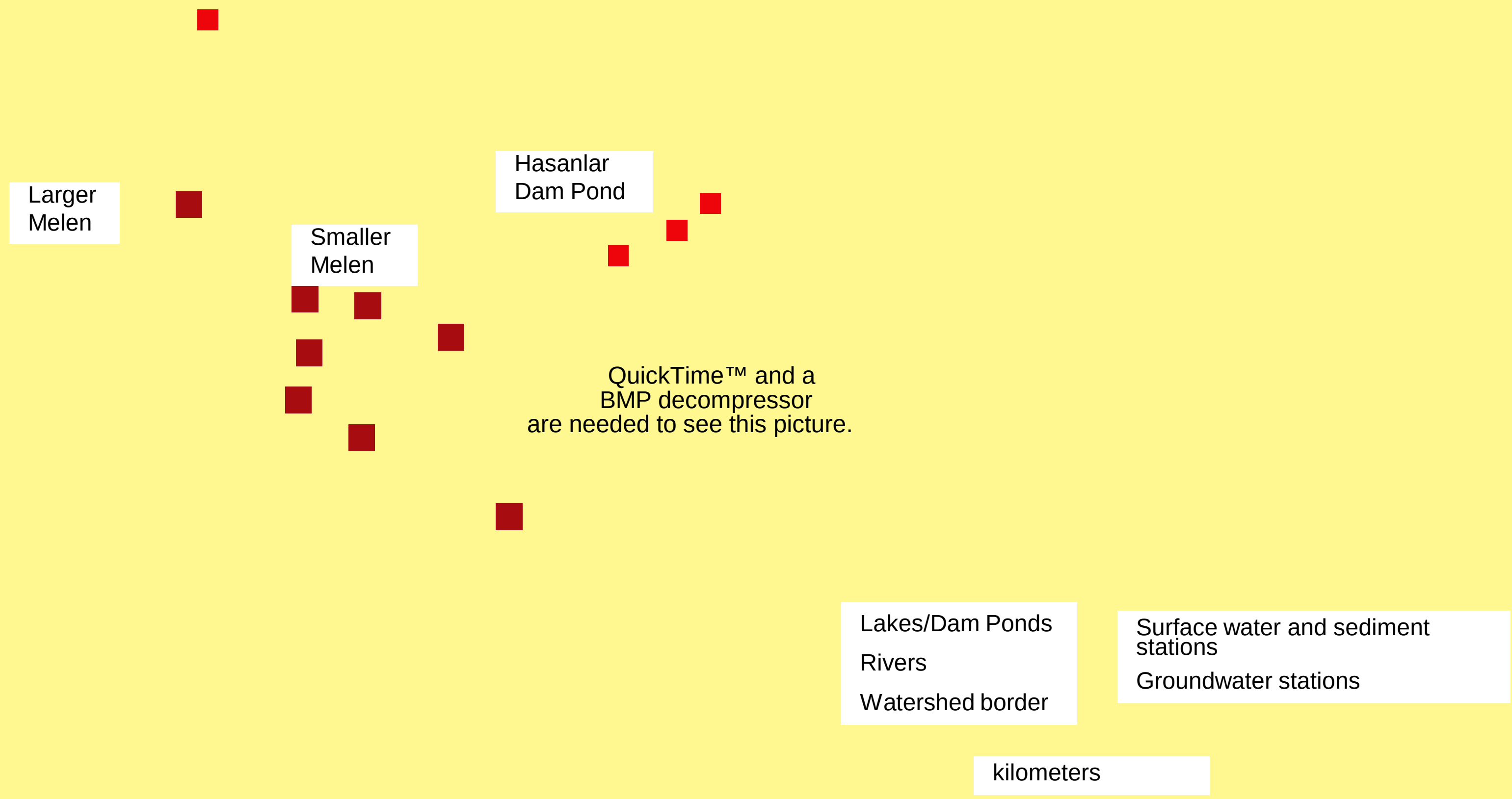
  are not being sufficiently addressed.

A Sustainable Watershed Management System is and should be:

- A must
- Continuous
- Flexible
- Multi-disciplinary
- Participatory
- Well-coordinated
- In consensus

Proposal:

- In the light of these requirements a multi-disciplinary watershed management system is being proposed.
- Melen Watershed is located at the western Black Sea Region of Turkey. Total area of 2437 km^2.



Proposal:

- In Melen Watershed apart from the conventional physical parameters, the following heavy metals and metals are proposed to be monitored: Pb, Cd, Cr, Zn, V, Ni, As, Cu, Fe, Mn, Sn, Al, Ba, B, Ca, Co, Li, Ag, Na, Mg, Mo, Sb, Tl.
- Sampling is conducted at all aquatic bodies and sediments in the Melen Watershed. In particular, soluble portion of the heavy metal concentrations are considered since they pose a risk for potable water resources.
- On a less frequent basis, sampling from groundwater wells, sediments and coastal surface soil (0-5 cm) will be conducted and analysed for metal concentrations.

Template of a Watershed Management System:

Monitoring

Parameters (pH, temperature, conductivity, dissolved oxygen, nitrogen, phosphorus, etc.)

Heavy metal concentrations and speciation

Ca^{2+}, Mg^{2+} ion concentrations

Flow path, hydrology, tributaries, pervious and impervious sites

Data Feed

Air pollution database

T-PRTR for industries (Turkish Pollutant Release and Transfer Register)

Turkish State Meteorological Service

Ministry of Environment and Urban Affairs

State Hydraulic Works

Institutional Resources (diversification of resources, stakeholders, key category analysis, etc.)

Template:

WATERSHED DATABASE*

Module 1:
Stressors (**heavy metals**, readily biodegradable organics, pesticides, endocrine disruptors, etc.)

Module 2:
Demographics (population, urban vs. rural, income level, etc.)

Module 3:
Land Use (agriculture, housing, industry, livestock etc.)

*Since output of one module affects the input of another, modules need to be communicating.

Template:

WATERSHED DATABASE*

Module 4:
Pollution sources (traffic, industrial emissions, heating, municipal wastewater, etc.)

Module 5:
Biodiversity (microbiota, plants, animals, species with conservation status, etc.)

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*Since output of one module affects the input of another, modules need to be communicating.

Template:

MODEL SELECTION

QUAL2K, WASP, BASINS, MOHID LAND, WinHSPF/AQUATOX, WMS, SWAT, etc.

OUTPUT

- EVALUATION OF THE CURRENT STATUS OF THE WATERSHED
- PROJECTIONS FOR THE STUDIED WATERSHED
- ENVIRONMENTALLY AND ECONOMICALLY BEST MANAGEMENT PRACTICES

Monitoring:

- Parameters such as
  - pH, temperature, conductivity and
  - dissolved oxygen, nitrogen, phosphorus and
  - biological diversity etc.

  can be used as precursors to pollution and predictors of mobility for certain pollutants.

  For example, **at low pH levels heavy metals are known to be mobilized by dissolving in water**. System stressor concentrations and speciation should be monitored to assess the current pollution status.

  - Overall system hydrology and hydraulics determine the physical borders of the pollution/management issue.
  - Uncertainty analysis and estimation of errors should be conducted with the experimental study

Data Feed:

- Existing data on
  - Meteorological events
  - System hydrology
  - Seasonal changes
  - Urban, agricultural and industrial activities

  should be retrieved from institutions in charge or databases regarding the size of the geographical watershed area that is picked (small watershed, large watershed, or river basin).
- Adoption of a Turkish version of European Pollutant Release and Transfer Register and prepare the relevant data in that particular format.

Data Feed:

- In order to utilize the limited institutional resources effectively strategies on diversification of resources should be conducted considering key category analysis.
- In the key category analysis the priority stressor/tributary/site should be selected for a given watershed and expenditure should be prioritized accordingly.
- In that regard it should be noted that the data feed section of the study would require serious efforts on data mining, quality assurance and quality check applications.
- John Nesbit was quoted "*We're drowning in information and starving for knowledge.*"

Watershed Database:

- The main idea is to handle the watershed as a whole with its
  - inhabitants (human, animal, plant or microbiota),
  - types of use,
  - types of pollutants, and
  - relevant stressors

  in terms of modules.

Therefore the aim is to achieve an integrated and sustainable watershed management system

Model Selection:

- Software packages that study the status of a wateshed at a given time and make projections are currently available.
- There are rather simpler models such as QUAL2K, which is solely a water quality model and one dimensional.
- There are more complex dynamic modeling tools such WASP that considers not only the water column but also the sediments.
- In addition, by using WASP one can study one to three dimensional systems.

Model Selection:

- A more recent modeling tool is BASINS, which is basically a system that puts the models for aquatic systems, hydrology, and biodiversity together.
- Another modeling tool, SWAT, deals with the land management practices and their foreseen effects on water and sediment, along with nutrient and pesticide quantities if the agriculture is the selected land use option.
- Other widely used modeling tools are MOHID, MIKE, MODFLOW and etc.

Output:

- Quality is assured
- Checked data is fed to the system
- The watershed-relevant modules are selected to represent the management problem at hand
- Appropriate models are selected and run.
- Spatial (GIS-supported maps) and temporal (time-series analysis) projections are made with regard to the watershed's past, current and future status.

Output:

- At this point different scenarios can be prepared (Monte Carlo Simulations)
  - by changing the land use type, and/or
  - by implementing control techniques to reduce industrial, agricultural and urban emissions, thus changing the emitted pollutant type and quantity.
- Economics of such changes including cost of implementation and operation and cost of caused environmental stress should also be included in the analysis, since sustainability requires economical and environmental feasibility simultaneously.

Watershed management system staff:

Engineering:

- Environmental
- Agricultural
- Meteorological
- Industrial
- Software/computer

Institutional:

- Ministry of Environment and Urban Affairs
- State Hydraulic Works
- Turkish State Meteorological Service
- Local authorities

Other Stakeholders:

- Industries
- Academia
- People that practice agriculture

CONCLUSIONS:

- A sustainable and integrated watershed management system is a requirement.
- An engineering approach to watershed management is to come up with a template that targets the problem at hand with all its components.
- A flexible modules approach, where the user can omit the unnecessary modules and integrate the necessary ones, is not only user friendly but also conveys to use of resources in a prioritized manner.

CONCLUSIONS:

- Since water is an economic and political good, the application of watershed management should be diligent.
- Therefore data acquisition from institutions is essential. Also quality assurance and quality check practices should be conducted on these data.
- Even though it increases the cost and the time-frame significantly, sampling studies should be conducted frequently at the appropriately determined sampling points.

CONCLUSIONS:

- Participatory essence of the management plan is planned to be procured by monitoring and reporting the health risks and economic deterioration that the inhabitants are exposed to by the pollution level at the watershed.
- Policy-makers, controlling/monitoring authorities, industries and people who sustain their livelihood from the watershed are all essential parts of the sustainable, participatory and integrated watershed management.

Thank you for listening

Any Questions and Contributions are appreciated.