Sediment production and dynamics in semi-arid regions
(The Wala Dam catchment, Jordan)

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Abstract

The Wala catchment (Fig.1) is an important water resource in Jordan, where water is extremely scarce. The Wala dam was built for artificial groundwater recharge. SWAT [1] was used to model hydrology and sedimentation processes within the catchment. Sediment samples were taken at the outlets of the model subbasins and the reservoir to examine chemicals transport using XRF analysis. A column experiment will be designed using reservoir sediment cores to investigate leaching and deposition of pollutants though sediment profile and the potential impact on recharge efficiency.

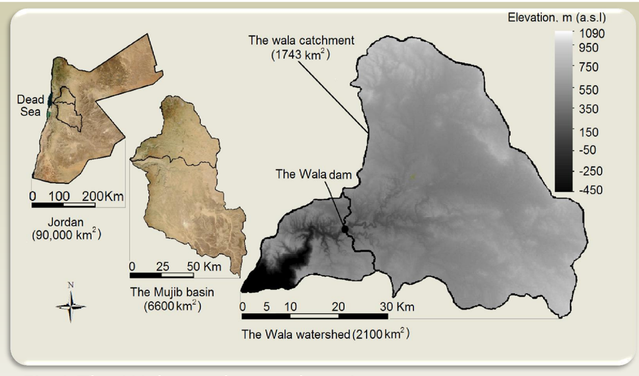

Fig 1 The Wala catchment location.

Research questions

1. What are the transport rates and yields of water and sediment within the catchment?
2. and how does variability of soil, landuse and weather affect them?
3. Do chemicals get transported from the catchment to the dam ?
4. Does sediment chemistry validate SWAT model predictions ?
5. Do contaminants accumulate in dam sediments ? And how ?

1. Hydrological modeling

Aim To build a pragmatic model able to simulate water and sediment within the Wala catchment.

Methods

Fig 2 shows the main features of the SWAT model. Steps (3-5) were repeated for 18 combinations of weather, landuse and soil datasets, of different specifications, and the optimum scenario (according to evaluation criteria) is shown here.

Fig 2 SWAT model flowchart

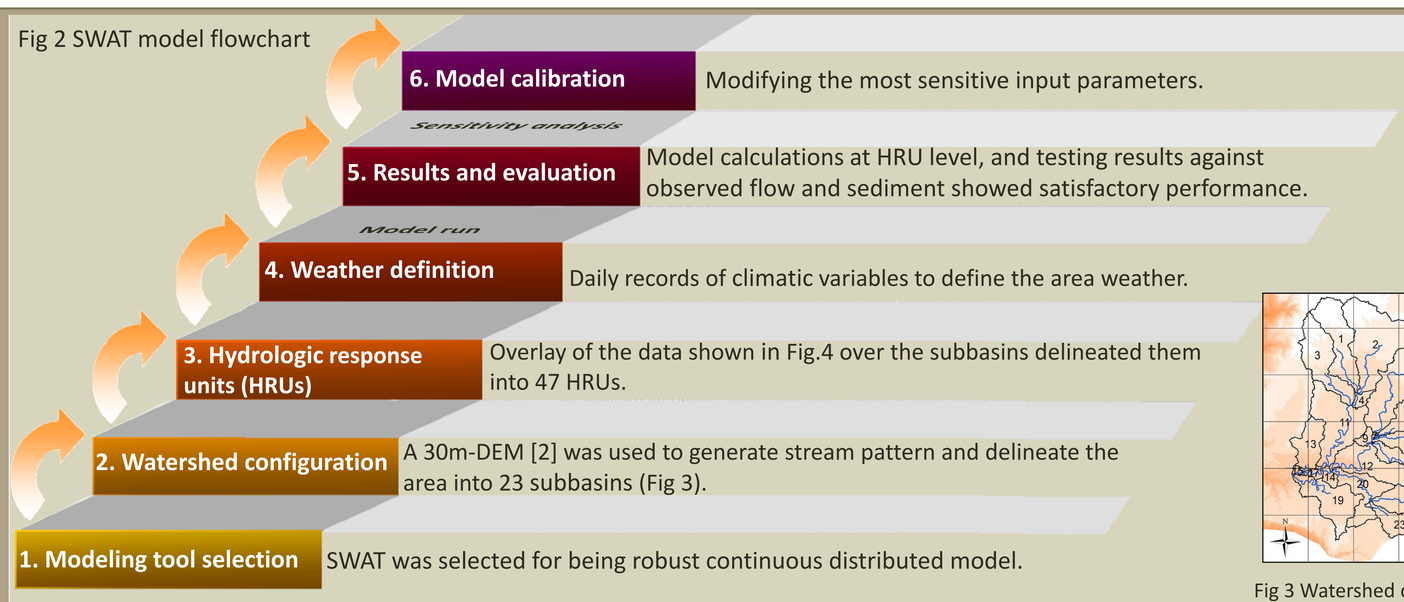

Fig 3 Watershed configuration.

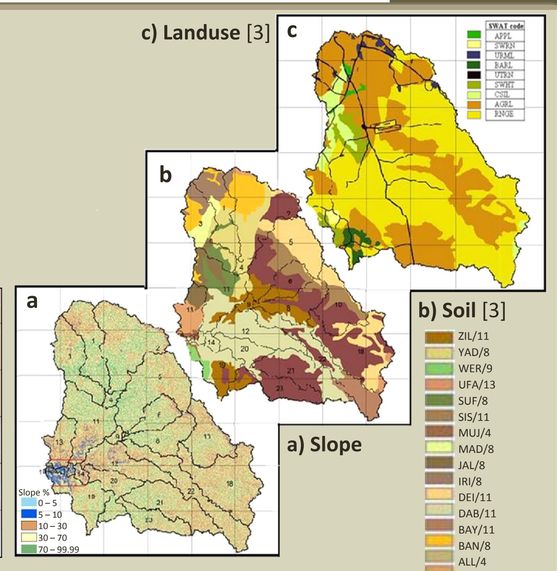

Fig 4 Data used for HRU definition.

Results

- The model is highly sensitive to weather and significantly to soil, with less sensitivity to landuse.
- Model performance using determination coefficient (r^2) and Nash-Sutcliffe efficiency (NSE)[4], and the optimum scenario showed satisfactory values (Table 1).
- Fig 5 shows the graphical display of the optimum scenario results and observed data.
- Western/northern areas receive higher precipitation and contribute more water and sediment to the dam.
- Model output will be linked to the results of experimental work targeting the catchment and dam sediments as below.

Table 1 Statistics of model evaluation calculated for the optimum scenario

Variable	r^2	NSE
Flow	0.67	0.56
Sediment	0.81	0.79

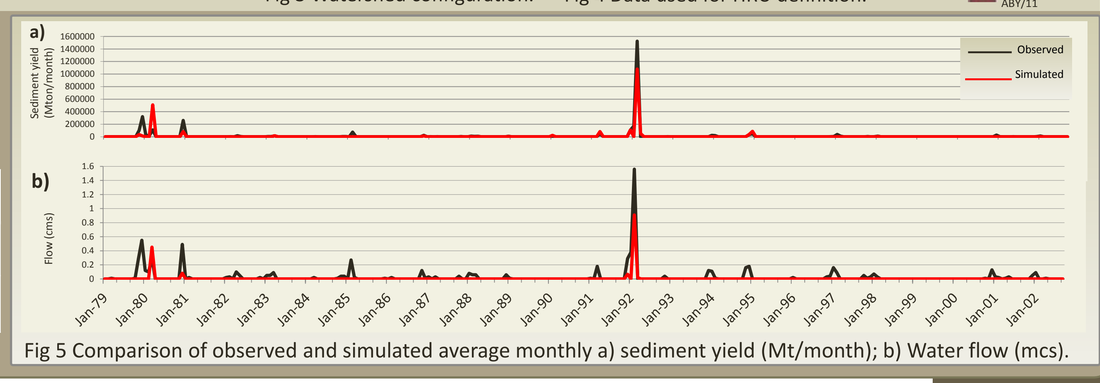

Fig 5 Comparison of observed and simulated average monthly a) sediment yield (Mt/month); b) Water flow (mcs).

2. From model to field (The Wala catchment , Jordan, Oct 2013)

Aim To sample sediments from the study area, based on the SWAT model subbasins.

Methods

- Sampling locations: subbasins outlets from the SWAT model.
- Required sampling: a) loose sediments from the catchment; b) cores from the reservoir bed.
- The samples were brought back to the UK for analysis.

Results

- Fifty sediment samples and five cores are available for analysis.
- The fieldtrip helped to observe important features of the area.

H.Abu-Rumman (left) and J.Bridge locating reservoir samples.

a) J.Bridge holding sediment core; b) the Wala reservoir; c) H.Abu-Rumman, J.Bridge and E.Tarawneh (Left to right), the Wala dam in the background; d) In the catchment.

Our potential contribution

Our project has attracted the attention of high level ministers and decision makers in Jordan, who showed strong keenness to cooperate with us to achieve its objectives, through which we hope to provide scientific investigation of pressing environmental challenges facing the country. In this context, we were invited to address a meeting of the Jordanian Society for Science and Culture (JSSC) and discuss the growing water crisis, and how our work can help to mitigate its impact.

Our participation was posted by Al-Ghad national newspaper as a good effort to bring the Jordan's most serious worry, water scarcity, to the international awareness.

The JSSC meeting, Amman 6th Oct 13

خبير بريطاني يحاضر حول أزمة المياه

عمان - الغد - عقدت الجمعية الأردنية للعلوم والثقافة اول من أمس ندوة حول الأزمة المائية في الأردن، تحدث فيها المحاضر بالهندسة البيئية بجامعة ليفربول البريطانية الدكتور جوناثان بريج.

واستعرض بريج أبرز أسباب الأزمة المائية العالمية والتغير المناخي، مقترحا بعض الحلول لها.

وشارك في الندوة مدير صندوق التعويضات البيئية في وزارة البيئة مروان سعيفان، حيث استعرض تاريخ قضية التعويضات وسبل إنفاقها، ودار حوار بين أعضاء الجمعية والمحاضر، ناقشوا خلاله طرق التغلب على الأزمة المائية في ضوء الضغط السكاني المتزايد في الأردن.

Al Ghad newspaper post of our participation [5].

3. From field to the UoL laboratories

A) X-Ray Fluorescence (XRF) analysis

Aim To assess transport and concentration of contaminants within the Wala catchment and reservoir sediments.

Methods

1. Chemical composition of catchment sediments (using bench XRF analysis Fig.7a-c):
2. XRF scanning of reservoir sediments (Fig.7d-h):

Results

The required comparisons will be done between chemicals concentrations in catchment and reservoir sediments to investigate their transport and accumulation.

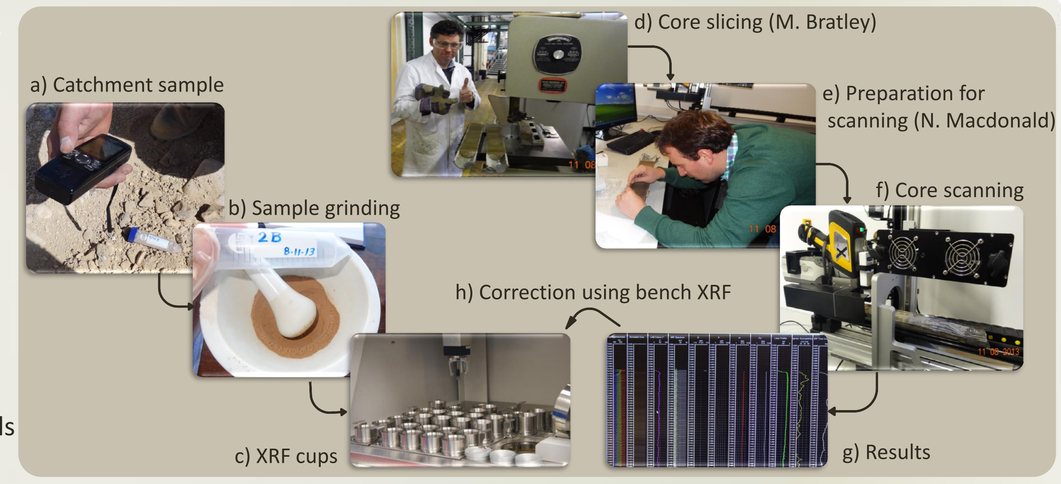

Fig 7 The XRF analysis: a-c) catchment samples (Bench XRF); d-h) reservoir cores scanning.

B) Leaching test (Future work)

Aim To examine the implications for water quality in the Wala dam recharge waters.

Methods

- A column experiment will be designed using reservoir sediment core/s.
- Artificial water will be applied to the designed column to study colloid formation and transport through sediment profile under different conditions.

Results

This part is expected to help in assessing the effect of sediment accumulation on groundwater recharge through the reservoir bed.

4. Conclusions

1. The SWAT model simulated the rates of flow and sediment yield with a good fit to observed values.
2. The model showed much higher sensitivity to the weather and soil than to landuse variability.
3. The XRF analysis will be used to validate the model and investigate pollutants transport within the area.
4. Leaching test results will help to assess the functionality of the reservoir bed in recharging groundwater.

References

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