A STUDY OF NUTRIENT DISCHARGE OF SIDI M'HAMED BENOUADA RESERVOIR (ALGERIA)

ACHITE Mohamed,* SAAD Hammoudi **

ABSTRACT

Stream discharge of nutrient elements (P,K,Na,S,Cl,NH_4^{+2},NO_3^{-2}) has been studied on Sidi M'hamed Benouada Reservoir for up to three years, seasonal sediments discharges of P and S are less than atmospheric inputs whereas Ca, Mg, K and Na exceed these inputs.

Seasonal nutrient discharges are dependent on water yield. Concentration behavior of nutrients during storms has been used to identify process within the reservoir influencing nutrient release from the watershed. During storms, three patterns of concentration behavior are observed: dilution of concentration increases during storm flow (Ca and Mg); concentration increases during storms (N and Mg); and little change in concentration (dissolved K, P, Na). These different patterns are caused by processes such as bedrock weathering, canopy and litter teaching, and expansion into variable source areas. Storm flow discharge is especially important in the transport of NH_4^{+2} and NO_3^{-2} and other elements primarily incorporated in organic matter.

Keywords: Reservoir, Nutrient discharge, Concentration, Algeria

---

* Department of Hydraulic, Faculty of Civil Engineering and Architecture
University of Science and Technology of Oran (031000), Algeria
E-Mail: achite_meddz@yahoo.fr

**Department of Hydraulic, Faculty of Science,
University of Chlef (02000) Algeria

1. INTRODUCTION

Many ecosystem scientists had studied on nutrient cycling by using experimental watershed and reservoirs for nutrient distribution and transport Henderson & Harris **[1]**, Dougil et al. **[2]**, Tam & Wong **[3].** In addition some experimental watersheds have manipulated to investigate the effects of vegetation conversion water quality, Grieve & Gilvear **[4],** Smith et al. **[5].**

The objectives of this study have been to:

- Increase the understanding of the basic factors controlling nutrient cycling processes within sediment.
- Quantify nutrient cycles for our watershed ecosystem in order to establish baseline data with which to compare patterns of nutrient cycling among different ecosystem types under different climatic vegetation and soil regimes.

The transfers (cycling) of nutrients between components are mediated by two carrier systems-water and biomass, House & Denison **[6].** The import of nutrients to a landscape by conducting cycling studies on experimental watersheds. The export of nutrients from the landscape in stream flow can be measured Zhao et al. **[7].** These data enable the analysis of nutrients cycling process within a watershed in light of the integrated behaviour with respect to the net nutrient accumulation or discharge. And; a large scope data on nutrient export in stream flow allow the interfacing of terrestrial and aquatic ecosystems with respect to the transport of nutrients.

We present the behaviour of **Sidi M'hamed Benouada** reservoir with regard to net accumulation or loss of nitrogen (Nitrate and Nitrite), Phosphorus, Calcium, Magnesium, Potassium, Sodium and discuss chemical processes with control the concentrations of these nutrients in stream water and therefore their discharge from the watershed materials and methods.

I. MATERIALS AND METHODS

The dam of **Sidi M'hamed Benouada** constructs 1973 to 1977 on the lower course of the Oued Mina; control a watershed of 6190 Km^2 has a capacity of 235 Hm^3 that includes the upper watershed controlled by the dam of Bakhada, which completes the action of this last dam. Which is situated 20 Km to the front of the city of Relizane. This earth dam was constructed to supply water to the city of Relizane and for irrigating of plane perimeter.
It regulates about 100 Hm^3 of flowing water a complained with Bakhada dam of 144 Hm^3/an.

The annual average flowing of the valley of this dam, estimate of 180 Hm^3 for watershed area of 4990 Hm^3 (Fig. 1).

The foundation geological structure is complex; it constituted of alternation of layers, with the lateral faces variations which complicated rapidly by effects of a loaded enough tectonic history.

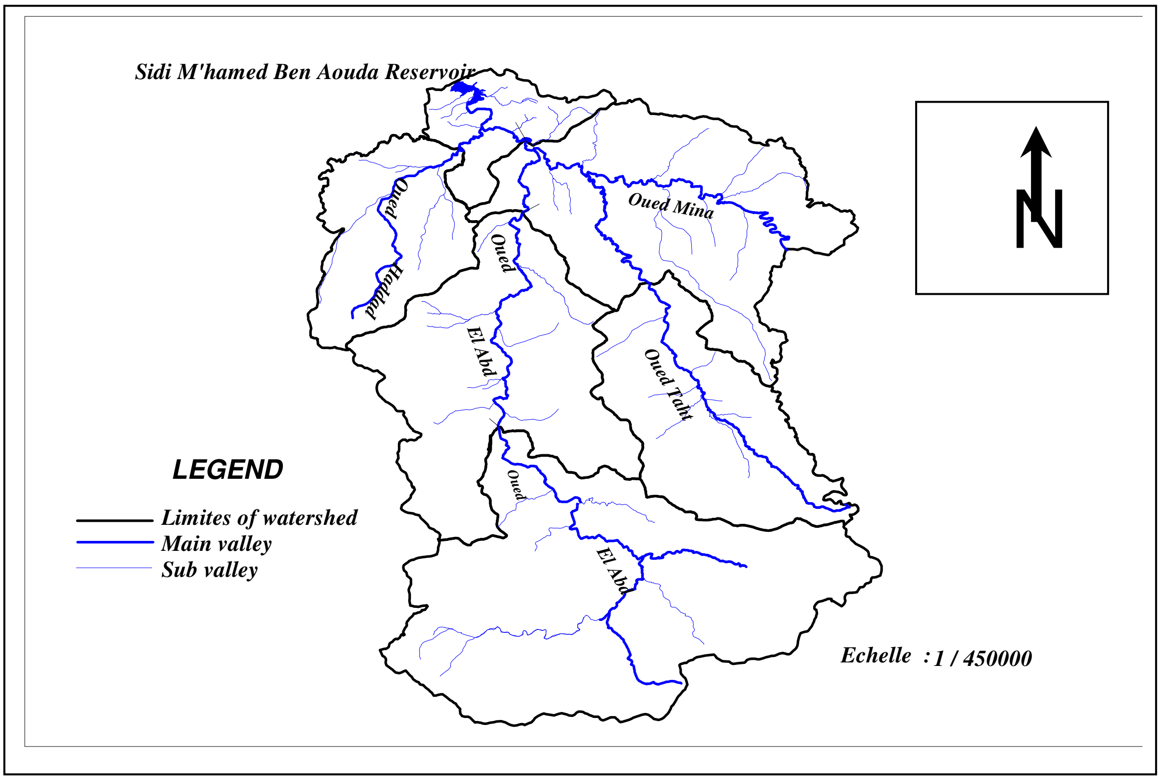

Figure 1: Watershed oued Mina situated

Nutrient balances for **Sidi M'hamed Benouada** reservoir are calculated from estimates discharge in stream flow. Samples of stream flow are composted proportional to discharge and collected weekly for each sub catchments under base flow conditions. During storm events when flow rate increases, separate samples are collected at (02) hours intervals in order to asses concentration changes associated with rapidly increasing and decreasing flow rates.

I.1 Sampling

A sample is pumped, from just below the notch in the weir, into a 10 l bottel after a predetermined flow through the weir. The composite of all of these samples is collected each week from each weir. Analyses are run on aliquots of the composted samples. If the discharge is so low that insufficient water was collected for analyses, a spot samples is taken at the time of samples pick up.

I.2 Pre-processing Preparation

Membrane filters, are washed with approximately 500 ml of filtered, distilled water. The filters are dried in a dissector, equilibrated to ambient conditions, and weighed, over to 0.01 mg. Porcelain crucibles, used in firing, are washed in detergent, soaked overnight in chromic acid cleaning solution, rinsed, and air dried. They are then fired to constant weight, equilibrated, and weighted to 0.01 mg.

I.3 Sample processing

An aliquot of 200-250 ml is taken from each well-shaken composite sample. The aliquot was stored, under refrigeration, until filtered, usually less than two weeks. The aliquot volume is accurately measured and all passed through a membrane filter. The filter is dried over desiccant, equilibrated to laboratory atmosphere, and weighed. The weight gain of the filter represents the total mass of particulate in the filtered volume. This is standardised to mg/l only every second filter is used for filtration. The weight change of the control filter is used to correct the weight change of the sample filter.

The sample filter is placed in apre-weighed crucible and fired for one hour at 1000°C. Weight gain of the crucible represents the mass of mineral matter in the sample. The difference between total mass and mineral phase represents the organic matter calcium, magnesium, potassium and sodium concentrations are measured by standard atomic absorption spectrophotometer techniques with lanthanum added to Ca determinations to eliminate interferences. Phosphate was determinate by the molyb date blue method; ammonium by indophenols blue, nitrate by reduction to nitrite and reaction with sulphanilamide; and sulphate by methyl-thymol blue. These analyses NO_3, NH_4^+ are all automated spectrophotometer methods (NH_4^+ and organic forms) was determined by Kjeldahal digestion and distillation and analysis of the distillate for ammonium as above.

II. RESULTS AND DISCUSSION

Elements can be classed on the basis of their behaviour with respect to net retention with landscape. For Oued Mina watershed, three classes of behaviour occur:

- Net loss (i.e., inputs < outputs) calcium and magnesium;
- Net accumulation (i.e., inputs > outputs > -nitrogen, phosphorus and sulphur;
- Little net change (i.e., inputs ≅ outputs) -potassium and sodium.

The annual balances which show these relationships are presented in Tables (1) and (2) for different elements. For calcium, the net annual loss averaged 79.45 Kg/Ha for 1999 - 2000, 2000 - 2001 (Table 1). Conversely, Ca out flow from the watershed was closely associated with hydrologic yield. Annual losses ranged from 74.60 Kg/Ha in

1999-2000 to 84.30 Kg/Ha in 2000-2001. For magnesium the losses from the watershed which dissolved in stream flow ranged from 59.1 Kg/Ha in 1999-2000 to 60.0 Kg/Ha in 2000-2001. The large losses of calcium and magnesium in stream water are due to weathering of the dolomite bed rock.

The amount of ca and mg discharge during a given years is a function of the amount of stream flow and the distribution of precipitation within any year, Wrenn et al. **[8]** And during summer discharge there will be greater amounts of Ca and Mg loss due to higher stream flow concentrations of these elements during this season.

For Nitrogen the average annual retention to the watershed dissolved in streamflow of 6.85 Kg/ha. The forms of nitrogen which studied are nitrate, ammonium and total forms, phosphorus inputs to **Sidi M'hamed Benouada Reservoir** was 0.54 and 0.48 Kg/Ha for 1999-2000 and 2000-2001 respectively (table 1). For sulphur (SO_4) the annual inputs occurs of 5.4 Kg/Ha.

A greater proportion of the annual inputs (44%) is being discharged in stream flow. For potassium anal sodium, the net loss was much less than for calcium and magnesium; and the annual potassium and sodium discharge increasing with larger, amounts of stream flow.

The sodium inputs were greatest during years higher precipitation. Patterns of streamflow nutrient concentration shows the changes during storms reveal processes controlling discharge from a watershed. These processes may be physically and chemically based such as due to geology. Soils and meteorology, or they may be biological such as those related to vegetation and land use, concentration changes during periods of changing steam flow discharge fall into three classes.

- Dilution - lower concentration during high discharge.
- Little or only seasonal changes in concentration.
- Higher concentration during high discharge.

For Oued Mina watershed magnesium and potassium concentration diluted during storms of Feb. Sodium concentration are concentrated, comparing with may storm.

Nitrate concentrations are seasonally concentrated, While Nitrate show little change in concentration during storms. These patterns will be illustrated in Figs. [1-7], these streamflow concentration data were collected during two storms; one in Feb. and the other in May Magnesium concentrations are predominantly influenced by the residence time of water with the nature of bedrock underlying the catchments. During Periods of increasing flow, magnesium concentrations decreases and when flow decreases magnesium concentration increases. During high flow regimes base flow, which has a long residence time with the bedrock, comprises a smaller proportion of the stream flow and is diluted by water arriving at the channel input. The amount of concentration decreases depends on the amount of storm flow relative to baseflow.

This relation ship holds during all seasons, although during winter storms which produce exceptionally high stream flow. Soil solution chemistry is more important than bedrock dissolution in controlling stream flow magnesium concentrations.

Nitrate and Sodium concentration patterns in streamflow are influenced by season of the year, Jordan **[9].** During late winter, summer and spring, Nitrate concentrations remain nearly constant during winter and especially Feb. storm, Nitrate concentration increases markedly during the initial period of a storm and the returns to the base flow concentration relatively quickly. Stream flow potassium concentration is primarily controlled by leaching through the soil profile for most of the year, however, in winter; vegetation is responsible for the higher concentration associated with initial stream flow increase. Nitrate is leachier from senescent leanness directly over the stream or fresh y fallen litter in the streambed giving use to higher stream flow concentrations.

Nitrogen concentrations in streamflow from Oued Mina watershed are closely associated with the hydrologic response of the catchments concentration changes during storms are due to transport of particulate organic and inorganic material. the pattern observed for individual storms most commonly consist of an initial of an initial decrease in concentration followed by an increase and then another decrease to level below those prior to storm initiation. The initial concentration decrease is caused by dilution from direct channel input the subsequent concentration increase is due to increased transport of particulate dislodged by high flow rates lower concentration at the end of the storm are the result of reduced amount available for transport because of the earlier flushing of materials. The highest concentration recorded for the two storms in however, peak concentration of, N have been measured for larger storms. During these period streams expand into Hydrologic source areas and transport material form intermittent drainages thus, Johnes **[10]**, Hydrologic source areas also important source of elements which are primarily transported from watersheds in particulate form.

Table (1) Annual balance for Calcium, Magnesium, Phosphorous, Sulphur, Potassium and Sodium on Oued Mina watershed.

Water years / Nutrient	Input Kg/ha	Out put Kg/ha	Net retention or loss Kg/ha
Calcium			
1999-2000	16.200	90.80	-74.600
2000-2001	15.300	99.60	-84.300
Two years average	15.750	95.20	-79.450
Magnesium			
1999-2000	3.600	62.70	-59.100
2000-2001	4.200	64.20	-60.000
two years average	3.900	63.45	-59.550
Phosphorous			
1999-2000	1.020	0.57	0.450
2000-2001	0.950	0.47	0.480
Two years average	0.985	0.52	0.465
Sulfur			
1999-2000	16.200	12.80	3.400
2000-2001	17.200	9.70	7.400
two years average	16.700	11.25	5.400
Potassium			
1999-2000	3.500	6.20	2.700
2000-2001	5.200	4.20	1.000
Two years average	4.350	5.20	1.850
Sodium			
1999-2000	3.600	5.20	-1.600
2000-2001	4.200	3.90	0.300
Two years average	3.900	4.55	-0.650

Table (2) Annual balance for Nitrogen, Amonical Nitrogen and Nitrate Nitrogen on Oued Mina watershed

Water Year / Nutrients	Input Kg/ha			Out put Kg/ha			Net Retention or loss Kg/ha
	Ammonium Nitrogen	Nitrate Nitrogen	Total Nitrogen	Ammonium Nitrogen	Nitrate Nitrogen	Total Nitrogen	
1999-2000	2.6	4.5	10.7	0.2	0.2	2.1	+8.6.
2000 - 2001	1.3	3.3	6.5	0.2	0.3	1.6	+5.1
Two years average	1.95	3.9	8.6	0..2	0.25	1.85	+6.85

Water year extends from September 1 to august 31 of the following year inputs are rain scavenged and dry particulate sedimentation.

Loss: last from the watershed dissolved in stream flow input minus output (« + » = retention « - » loss).

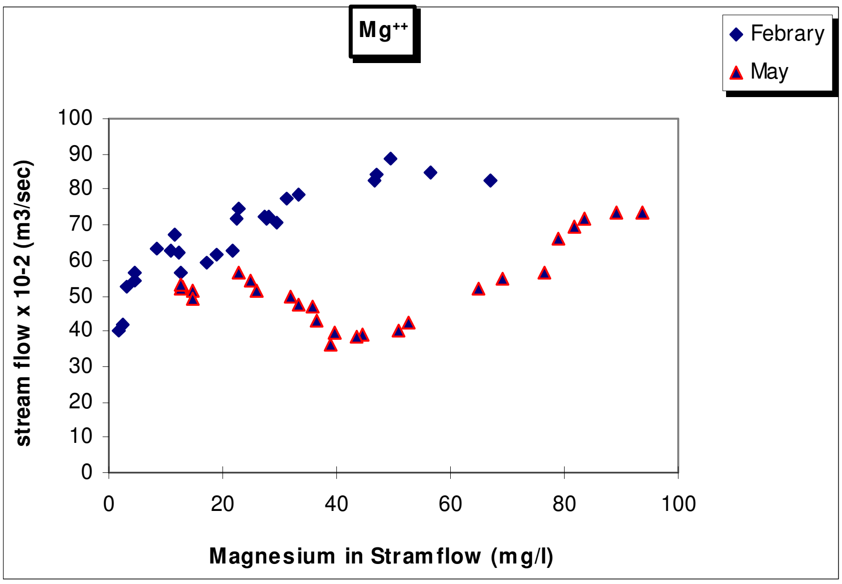

Figure2: Relationships between magnesium concentration in streamflow and discharge rate for February and May storms on Oued Mina watershed.

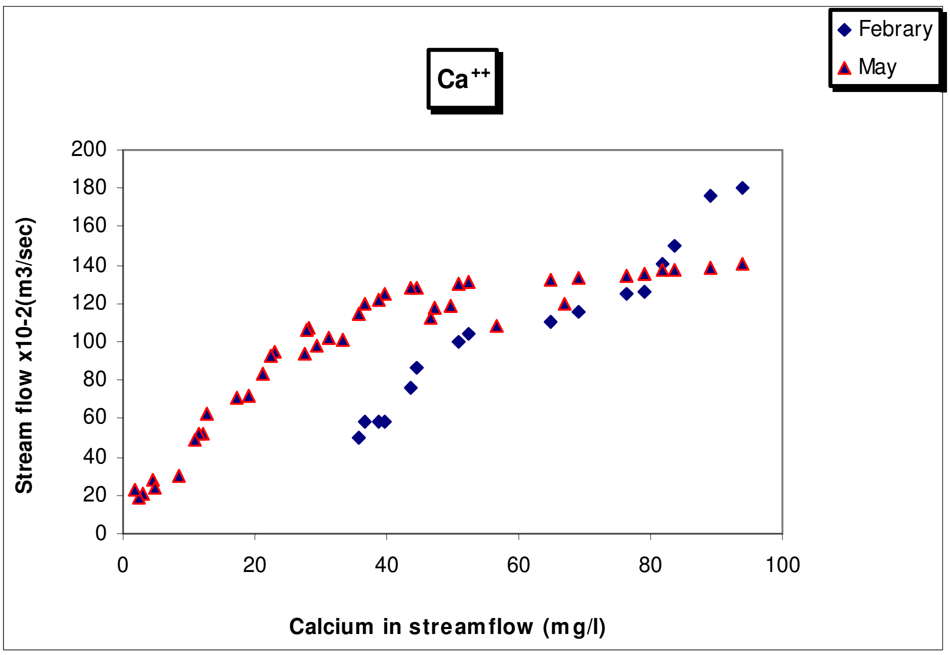

Figure 3: Relationships between potassium concentration in streamflow and discharge rate for February and May storms on Oued Mina watershed.

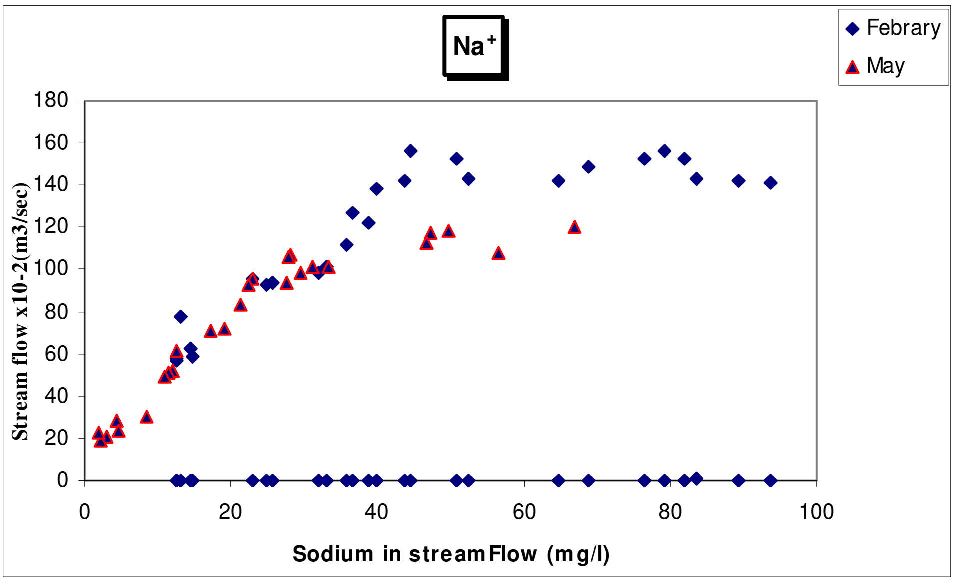

Figure 4: Relationships between calcium concentration in streamflow and discharge rate for February and May storms on Oued Mina watershed

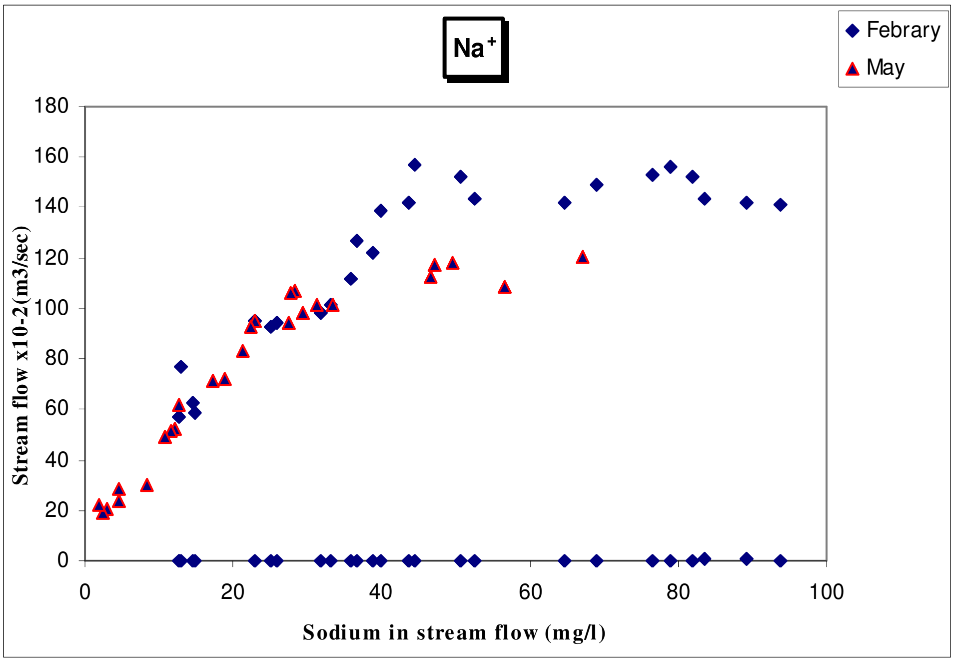

Figure 5: Relationships between sodium concentration in stream flow and discharge rate for February and May storms on Oued Mina watershed

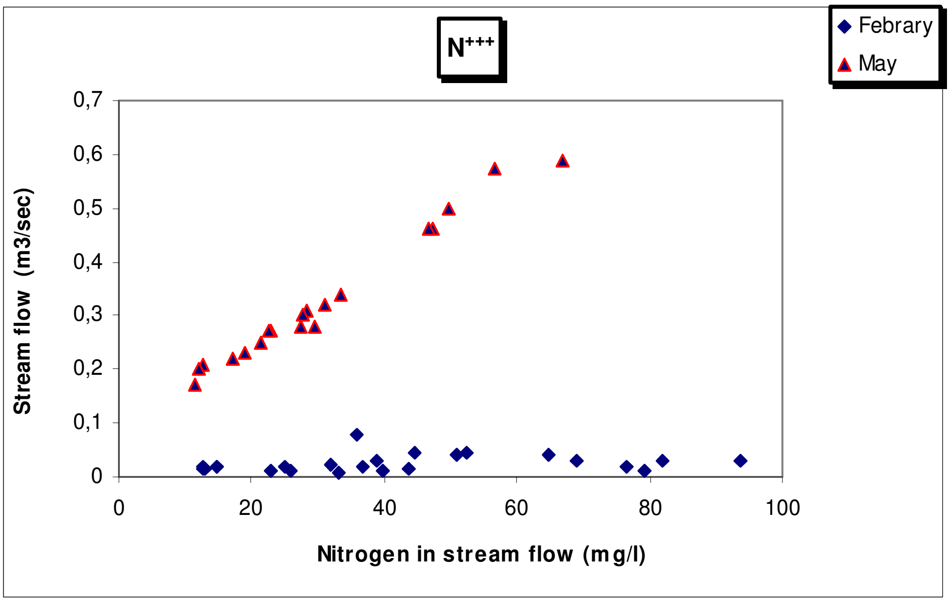

Figure 6: Relationships between Nitrogen concentration in streamflow and discharge rate for February and May storms on Oued Mina watershed

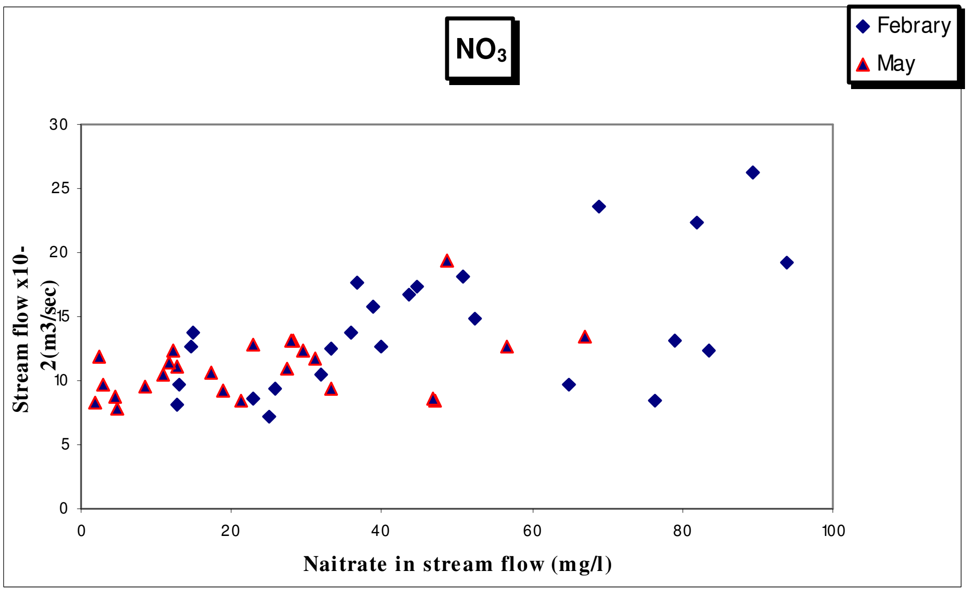

Figure 7: Relationships between Nitrate concentration in stream flow and discharge rate for February and May storms on Oued Mina watershed

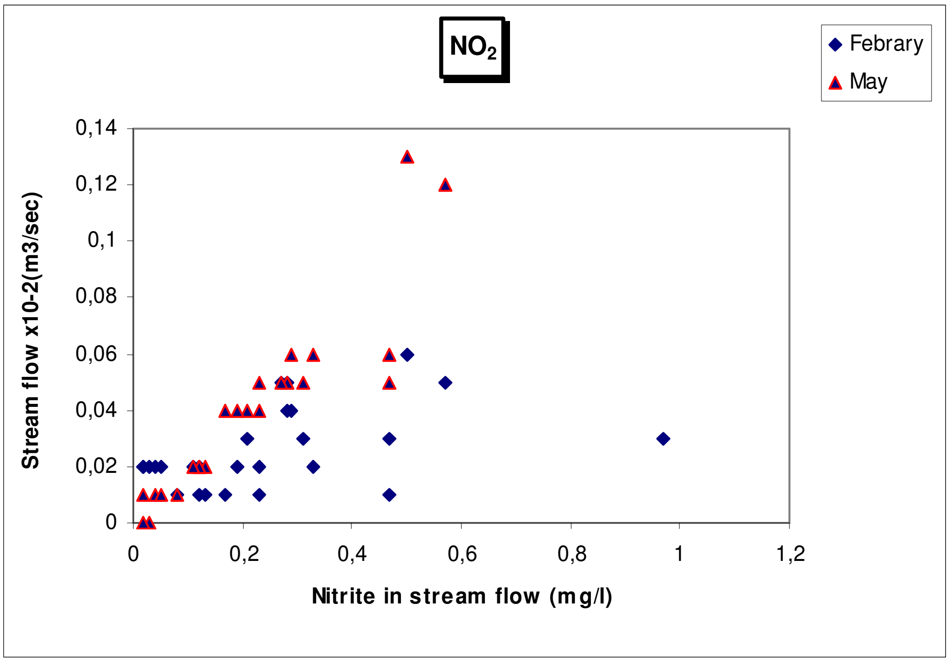

Figure 8: Relationships between nitrite concentration in stream flow and discharge rate for February and May storms on Oued Mina watershed

CONCLUSION

The study of nutrient discharge behaviour and its effect on the sediment load of reservoir and dam got a real attention for this problem which leads for more progressive studies of the different patterns of sediment accumulation and the type of sediment nutrient and its transporting during rain storm and current flow. So, we have to study these parameters carefully to get accurate results about this phenomenon.

REFERENCES

[1] **Henderson G.S. and HARRIS W. F.,** An ecosystem approach to characterisation of the nitrogen cycle in deciduous forest watershed, forest soils and forest land management, edited by Bernier, B. and Winget, C.H., Laval, Quebec, Canada, pp. 179,1975.

[2] **Dougil A. J., Heatwaite A. L. and Thomas D. S. G.,** Soil water movement and nutrient cycling in semi- arid Rangeland :Vegetation change and system resilience, Journal of Hydrol. Process, Vol. 3, pp. 443-459, 1998.

[3] **Tam N. F. Y. and Wong Y. S.,** Variations of soil nutrient and organic matter content in a subtropical mangrove ecosystem, Journal of Water Air Soil Pollut., Vol. 1-4, pp. 245-261, 1998.

[4] **Grieve I. C. and Gilvear D. J.,** Quantifying anthropogenic nutrient sources and loadings within a small catchment with conservation interests, eastern Scotland, Journal of Aquatic Conservation, Vol. 4, No. 3, pp. 273-287, 1994.

[5] **Smith S. V., Chambers R. M. and Hollibaugh J. T.,** Dissolved and particulate transport through a coastal watershed-estuary system, Journal of Hydrology, Vol. 176, No. 1-4, 1996.

[6] **House W. A., Denison F. H.,** Nutrient dynamics in a lowland stream impacted by sewage effluent; Great ouse, England, Sci. Total Environ., Vol. 205, No. 1, pp. 25-49, 1997.

[7] **Zhao H., Hao O. and Mcavoy T. J.,** Modelling nutrient dynamics in sequencing batch reactor, Journal of Environ. Eng., Vol. 123, No. 4, pp. 311-319, 1997.

[8] **Wrenn B. A., Suidan M. T. and Strohmeier K. L.,** Nutrient transport during bioremediation of contaminated beaches: evaluation with lithium as a conservative tracer, Journal of Water Research, Vol. 31, No. 3, pp. 515-524, 1997.

[9] **Jordan T. E., Correll D. L. and Weller D. E.,** Relating nutrient discharges from watersheds to land use and streamflow variability, Journal of Water Resur. Res., Vol. 33, No. 11, pp. 2579-2590, 1997.

[10] **Johnes P. J.,** Evaluation and management of the impact of land use change on the nitrogen and phosphorus load delivered to surface waters: The export coefficient modelling approach, Journal of Hydrology, Vol. 183, No. 34, pp. 323-349, 1996.