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Understanding the Mechanism of Nutrient Transport through Surface Runoff

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Abstract
Eutrophication and associated ecological changes in water bodies have become a major environmental challenge. Therefore, understanding of the transport mechanism of nutrients into the water bodies is of importance, as it will help in managing the problem of eutrophication. In this study, surface runoff samples were analyzed for the nutrients during the rainfall events in the watershed of Sukhna Lake, Chandigarh (India). The monitoring point was selected in the drain in which all the sub-drains merged into. The Chemographs plotted suggested that the mechanism of transport of total phosphorous (TP) was majorly adsorbed onto suspended solids whereas the total nitrogen (TN) was transported in solution.

Keywords: *Nutrients, Eutrophication, Transport mechanism, Surface runoff*

INTRODUCTION

The transport of nutrients, particularly total nitrogen (TN) and total phosphorous (TP), into rivers, lakes and other surface water bodies has attracted attention due to the growing problem of eutrophication. There is a great need to understand the cycling of nutrients through terrestrial and aquatic ecosystems. In watersheds, where erosion rates and sediment yields are high, the sediment-associated component of the total N and P loads will commonly be dominant. Where erosion rates are low and effluent inputs are a major source, the dissolved component may dominate. Also, extreme discharge events account for a major loss of nutrients. Gentry et. al. studied phosphorous transport in an experimental tile drained agricultural watershed and found that the total phosphorous loads were greatly increased by overland runoff [1]. Creed et. al. in their assessment of export of nitrogen from catchment within a temperate forest, observed that the transport depended upon the topography [2]. It was reported that the catchment with a greater lateral expansion of source area would have longer flushing time and higher rates of nitrate export while the catchment with a lesser rate of lateral expansion of source area showed a lower rate of nitrate-nitrogen export. The major inputs of phosphorous and nitrogen to soil are from fertilizers, animal wastes and crops residues [3]. Richards et. al. studied Lake Erie basin for pesticide-nutrient concentration pattern with storm runoff and proposed the use of chemo graph in understanding their pattern [4]. Rainfall events lead to sediment-nutrient mobilization and agricultural based nutrient loading is sediment assisted [5]. In residential catchments of USA, atmospheric deposition followed by fertilizers was the source of nitrate whereas the erosion of soil and mineralization of organic matter contributed in phosphorous concentration [6]. Rainfall intensity has a significant effect on runoff, sediments and associated nutrient loss [7]. In this paper, an attempt is made to understand the transport mechanism of the nutrients through the surface runoff during the rainfall events.

STUDY AREA

Figure 1 shows the study area, the watershed of Sukhna lake, Chandigarh (India). The watershed is approximately 42 km^2 which consist of about 85% area under forest cover, 6% under built up and remaining under agricultural activities as the major land use. The mean slope of the area is 6.2^0. The monitoring point was on the main drain to which all the sub-drains merged, as shown in Fig 1.

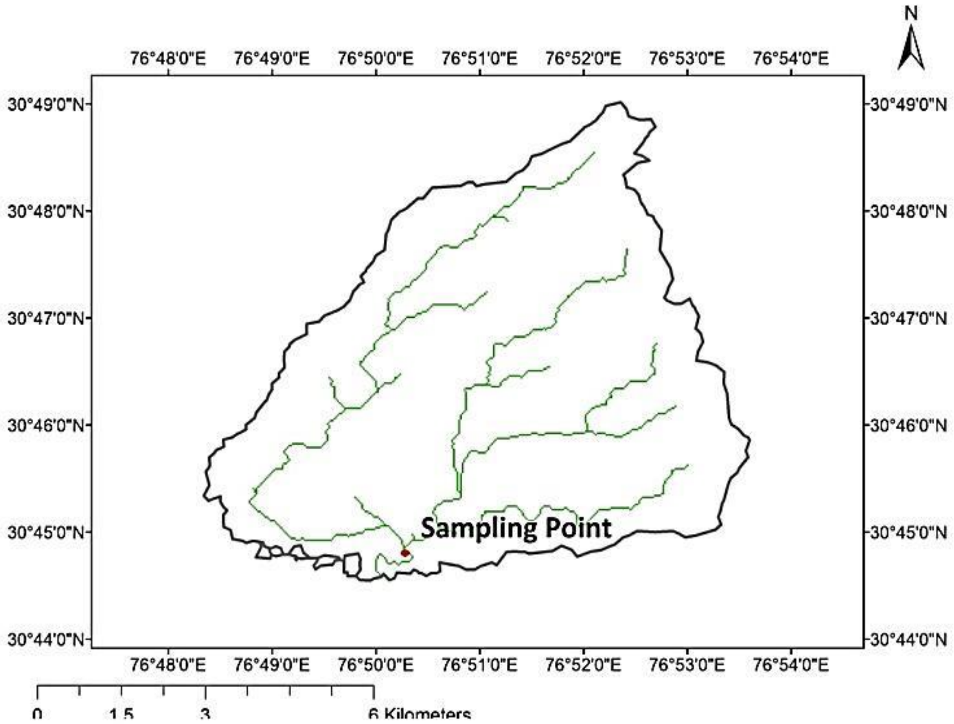

Figure 1: *The study area and the sampling point.*

METHODS

Surface Runoff Monitoring

To study the transport of nutrients through the surface storm runoff, concentrations of nutrients and suspended solids in the storm runoff were measured during and after the rainfall. The study was conducted during three major rainfall events in December 2018. The average rain fall intensity was 4 mm/h for duration of 2-3 h. The sampling was continued for 9 consecutive days after the rainfall. Samples were collected and analyzed for suspended solids, total nitrogen and total phosphorous concentration and chemographs were plotted.

Laboratory Analysis

Three grab samples every day during the monitoring period were collected in 500 ml plastic bottles for determination of total suspended solids, total phosphorous and total nitrogen. Measurement of the Total Suspended Solids (TSS) was done by drying at 103^0 C-105^0 C and Total Phosphorous (TP) concentration of the samples was estimated by the ascorbic acid method as per Standard Methods [8]. Total Nitrogen (TN) concentration measurement was done by using Ultraviolet spectrophotometric method [9]. To digest the samples for total nitrogen and total phosphorous concentration measurement, per sulfate oxidation method was used. The per sulfate oxidation method renders a digestate that can be analyzed for both total nitrogen and total phosphorous. The nitrogenous compounds are oxidized to nitrate and phosphorous compounds to orthophosphate.

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RESULTS AND DISCUSSION

Nutrients Concentration

The concentrations of the TSS, TN and TP observed in the surface runoff samples are shown in Table 1. The data presented are average of the samples collected during the study period.

Table 1: *Concentration of the TSS, TN and TP.*

Day	TSS (mg/l)	TN (mg/l)	TP (mg/l)
1	1304 ± 48	3.2 ± 0.2	0.4 ± 0.1
2	1360 ± 74	3.3 ± 0.2	0.5 ± 0.2
3	2368 ± 68	6.9 ± 0.1	2.4 ± 0.2
4	1888 ± 82	6.6 ± 0.1	1.2 ± 0.1
5	1512 ± 61	6.5 ± 0.2	1.0 ± 0.2
6	1412 ± 37	6.6 ± 0.1	0.9 ± 0.1
7	1484 ± 76	6.4 ± 0.3	0.9 ± 0.1
8	1336 ± 50	6.5 ± 0.3	0.6 ± 0.2
9	1366 ± 74	6.5 ± 0.2	0.7 ± 0.1

The chemo graphs showing the variation in the concentration of suspended solids and the nutrients with time during and after the rainfall events are shown in Figure 2. It can also be seen from the figure that the peaks are formed by day 3.

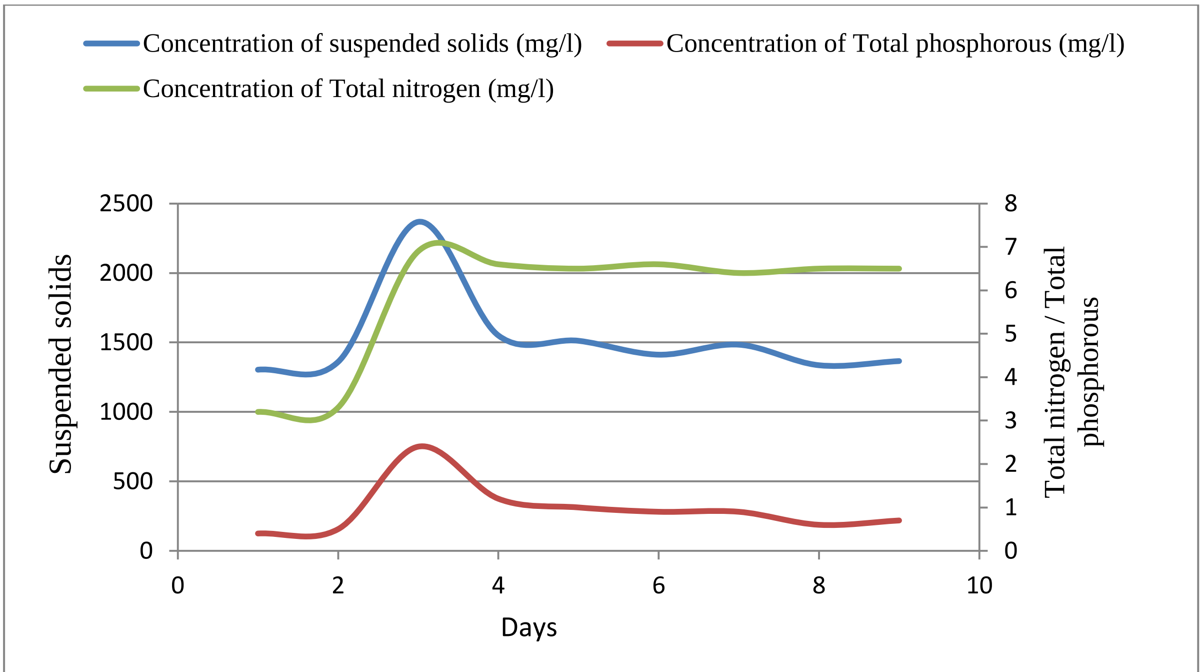

Figure 2: *The Chemographs.*

Concentration of total nitrogen

It can be seen from figure 2 that both suspended solids and total nitrogen peaked on day 3 at 2368 mg/l and 6.9 mg/l, respectively. The concentration of suspended solids decreased in the drainage up to day 6, the TN content didn't change significantly after day 4. After day 4, the TN content is almost stabilized at about 6.4 mg/l – 6.6 mg/l whereas, the suspended solids stabilized beyond day 6. From this, it could be inferred that the majority of the TN content is getting transported in solution. Similar observations have been reported by other researchers. Suspended associated transportation of total nitrogen generally varied between 3.3 % - 8.8 % only [10]. Most of the total nitrogen transport takes place in solution to the water because of its high solubility in water.

Concentration of total phosphorous

Figure 2 also, indicates that the concentration of suspended solids and total phosphorous reaches to the peak on the 3rd day at 2368 mg/l and 2.4 mg/l, respectively. The total suspended solids and total phosphorous concentration showed a decreasing trend up to day 6. It can be inferred that the majority of total phosphorous transports getting attached to the solids. On day 4, the concentration of the TP decreases sharply along with the TSS. In river Avon and Seeren suspended associated TP load was 43.2 % and 26.3 % for two different streams [10]. The suspended associated TP load could also be explained based on its low solubility in water.

It was reported that the concentration of the nutrients in surface runoff was dependent on the suspended solids, either as attached or suspended [11]. The observations of this study also corroborate this postulation of nutrients transport associated with suspended solids with varying degrees of association.

CONCLUSION

The nutrients (TN and TP) transport through surface runoff is closely associated with the TSS. The major transport mechanism in case of the TN is in dissolved form rather in the suspended associated form. Whereas, the TP mainly gets transported in suspended form along with suspended sediment-particles. It could be concluded that the management strategies to prevent nutrients ingression required appropriate approaches to address the phase in which the respective nutrient is present in the storm runoff.

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