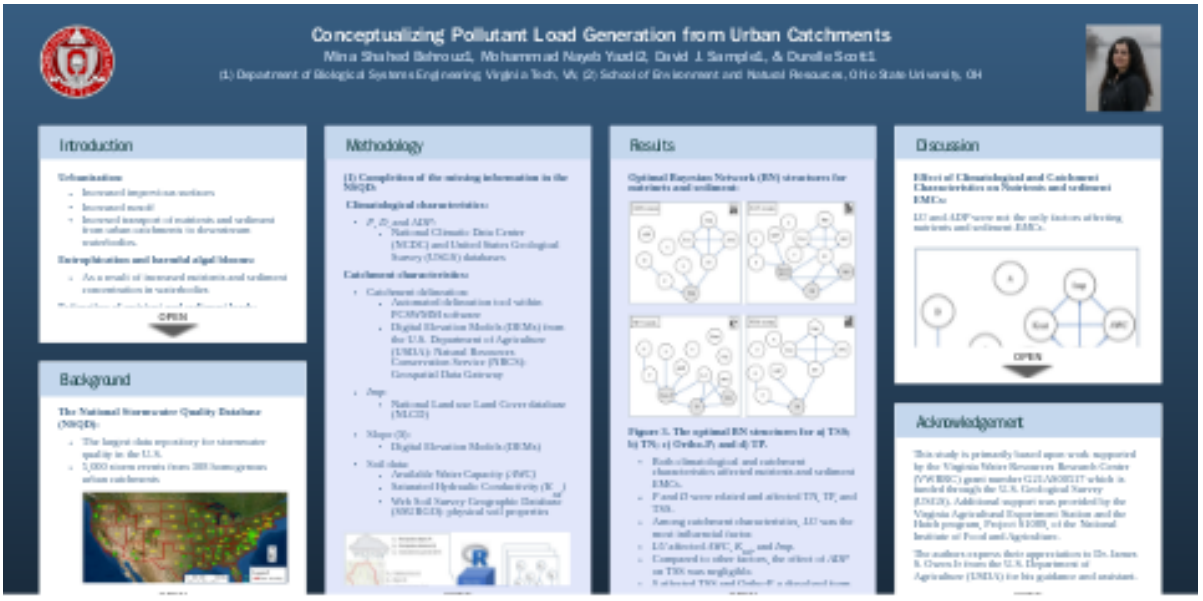
Conceptualizing Pollutant Load Generation from Urban Catchments



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PRESENTED AT:

INTRODUCTION

Urbanization:

- Increased impervious surfaces
- Increased runoff
- Increased transport of nutrients and sediment from urban catchments to downstream water bodies.

Eutrophication and harmful algal blooms:

- As a result of increased nutrients and sediment concentration in water bodies

Estimation of nutrient and sediment loads:

- Design of stormwater control measures (SCMs) or best management practices (BMPs) is based on inflow loads from urban catchments.
- Event Mean Concentration (*EMC*) is a common practice used by practitioners to estimate stormwater quality from a specific land use (*LU*).
  Pollutants accumulate on surfaces during dry periods, making *EMC* a function of antecedent dry period *(ADP)*. An *EMC* results from wash-off of accumulated pollutants from catchment surface during runoff events. However, several studies have not found a correlation between constituent concentrations in stormwater and *ADP*.

The objective of this study:

- Discover which climatological or catchment characteristics are most significant in affecting nutrients and sediment *EMCs*.

BACKGROUND

The National Stormwater Quality Database (NSQD):

- The largest data repository for stormwater quality in the U.S.
- 5,000 storm events from 308 homogenous urban catchments

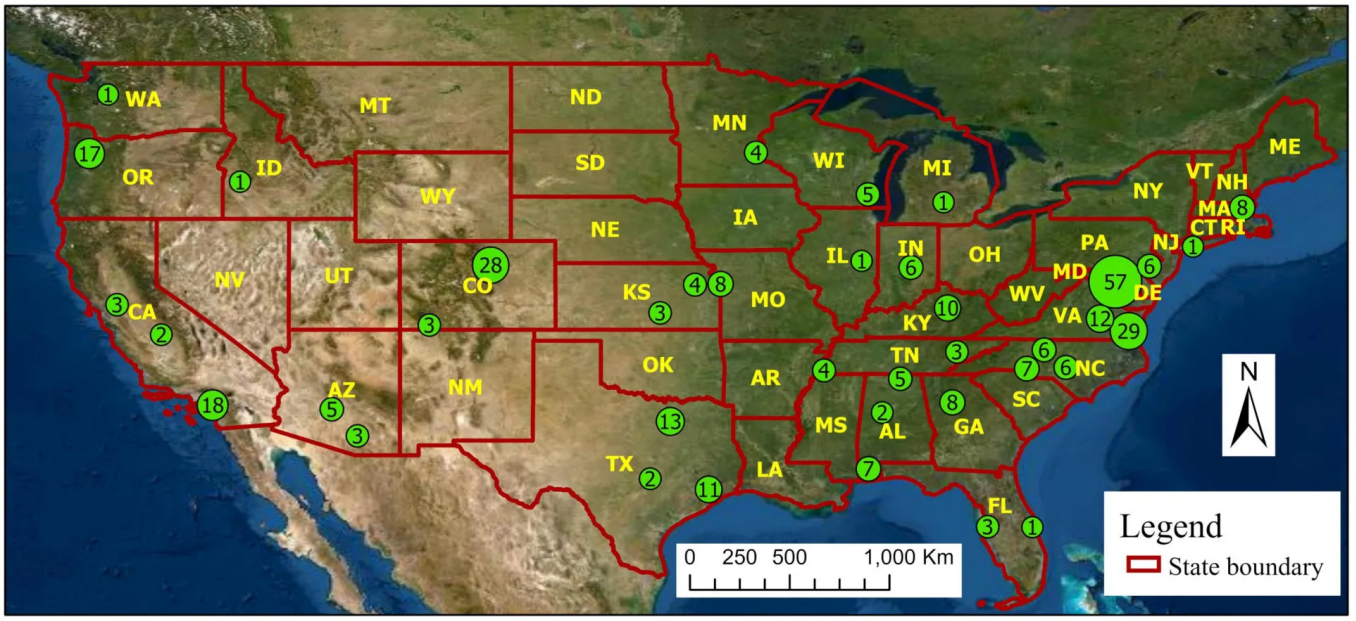


Figure 1. The number of monitoring locations with homogenous urban catchments in the NSQD.

- Water quality constituents:
  - Total Nitrogen (TN)
  - Total Kjeldahl Nitrogen (TKN)
  - Nitrate (NO_3-N) and Nitrite (NO_2-N)
  - Total Phosphorous (TP)
  - Ortho-Phosphorous (Ortho-P)
  - Total Suspended Solids (TSS)
- Land uses (*LUs*):
  - Commercial, Freeways, Industrial
    Institutional, Open Space, and Residential
- Recoded data for each storm event:
  - Catchment size (A)
  - Percent imperviousness (Imp)
  - LU
  - Precipitation depth (P)
  - Precipitation duration (D)
  - ADP

METHODOLOGY

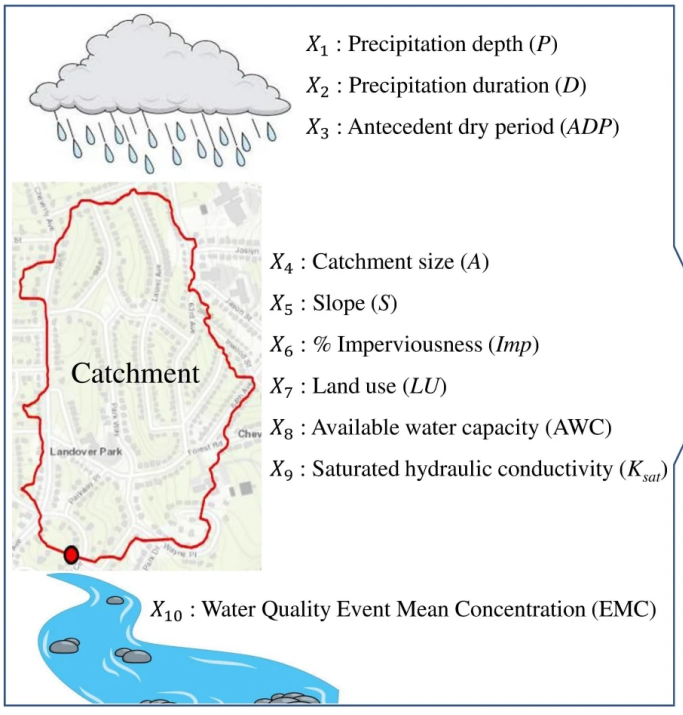
(1) Completion of the missing information in the NSQD:

Climatological characteristics:

- *P*, *D*, and *ADP:*
  - National Climatic Data Center (NCDC) and United States Geological Survey (USGS) databases

Catchment characteristics:

- Catchment delineation:
  - Automated delineation tool within PCSWMM software
  - Digital Elevation Models (DEMs) from the U.S. Department of Agriculture (USDA): Natural Resources Conservation Service (NRCS): Geospatial Data Gateway
- *Imp*:
  - National Land use Land Cover database (NLCD)
- Slope (*S*):
  - Digital Elevation Models (DEMs)
- Soil data:
  - Available Water Capacity *(AWC)*
  - Saturated Hydraulic Conductivity *(K_{sat})*
  - Web Soil Survey Geographic Database (SSURGO): physical soil properties



The optimal Bayesian Network structure

Figure 2. General overview of the methodology used in this study.

(2) Bayesian Network Structure Learner (BNSL):

- Widely used machine learning method.
- Freely available within R programming language.
- Performs pairwise independence tests among any pair of variables.
- Models dependencies among random variables.

RESULTS

Optimal Bayesian Network (BN) structures for nutrients and sediment:

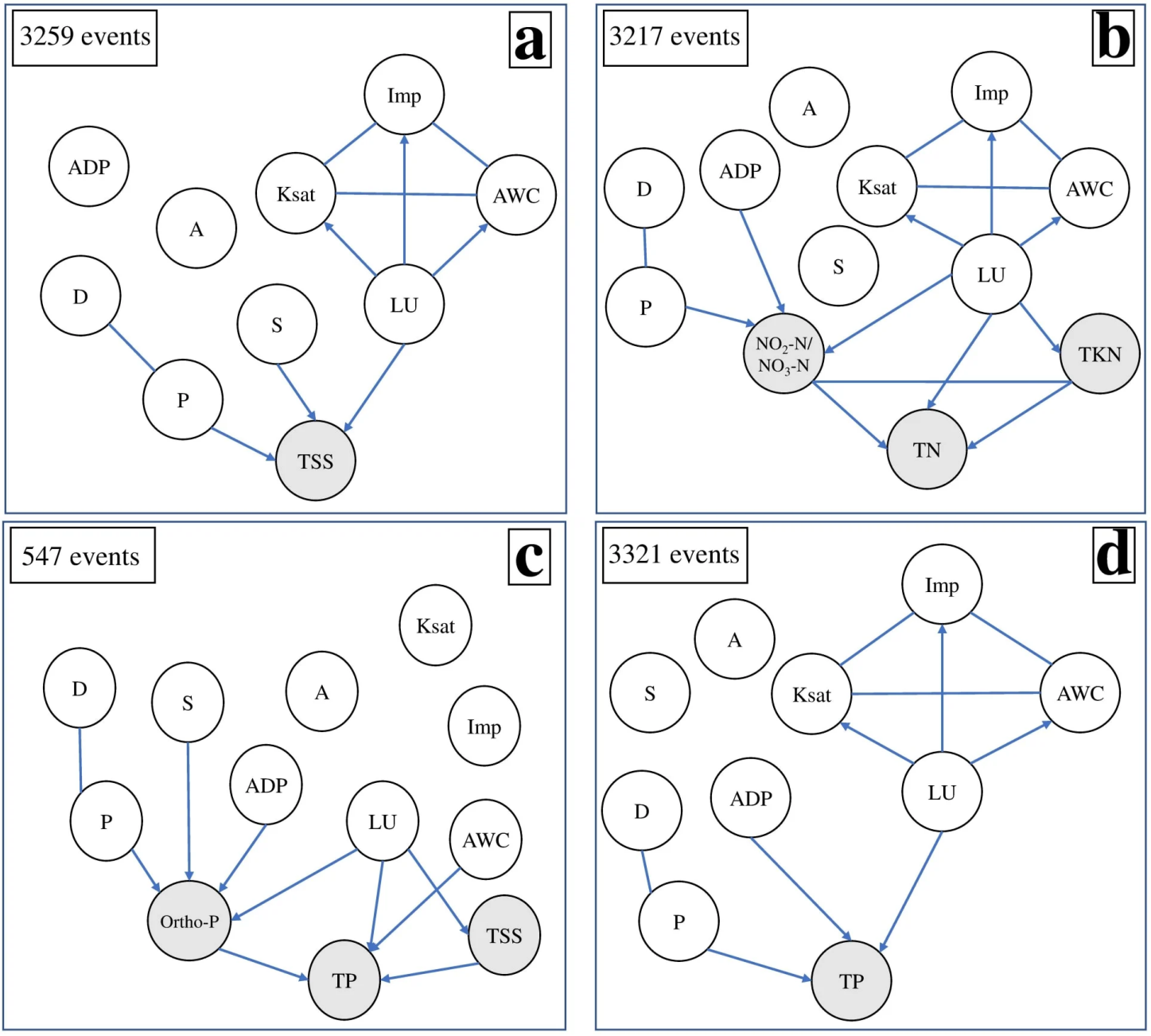


Figure 3. The optimal BN structures for a) TSS, b) TN, c) Ortho-P, and d) TP.

- Both climatological and catchment characteristics affected nutrients and sediment *EMCs*.
- *P* and *D* were related and affected TN, TP, and TSS.
- Among catchment characteristics, *LU* was the most influential factor.
- *LU* affected *AWC, K_{sat},* and *Imp*.
- Compared to other factors, the effect of *ADP* on TSS was negligible.
- *S* affected TSS and Ortho-P, a dissolved form of TP.

- TSS affected the particulate form of TP.

DISCUSSION

Effect of Climatological and Catchment Characteristics on Nutrients and sediment EMCs:

LU and *ADP* were not the only factors affecting nutrients and sediment *EMCs*.

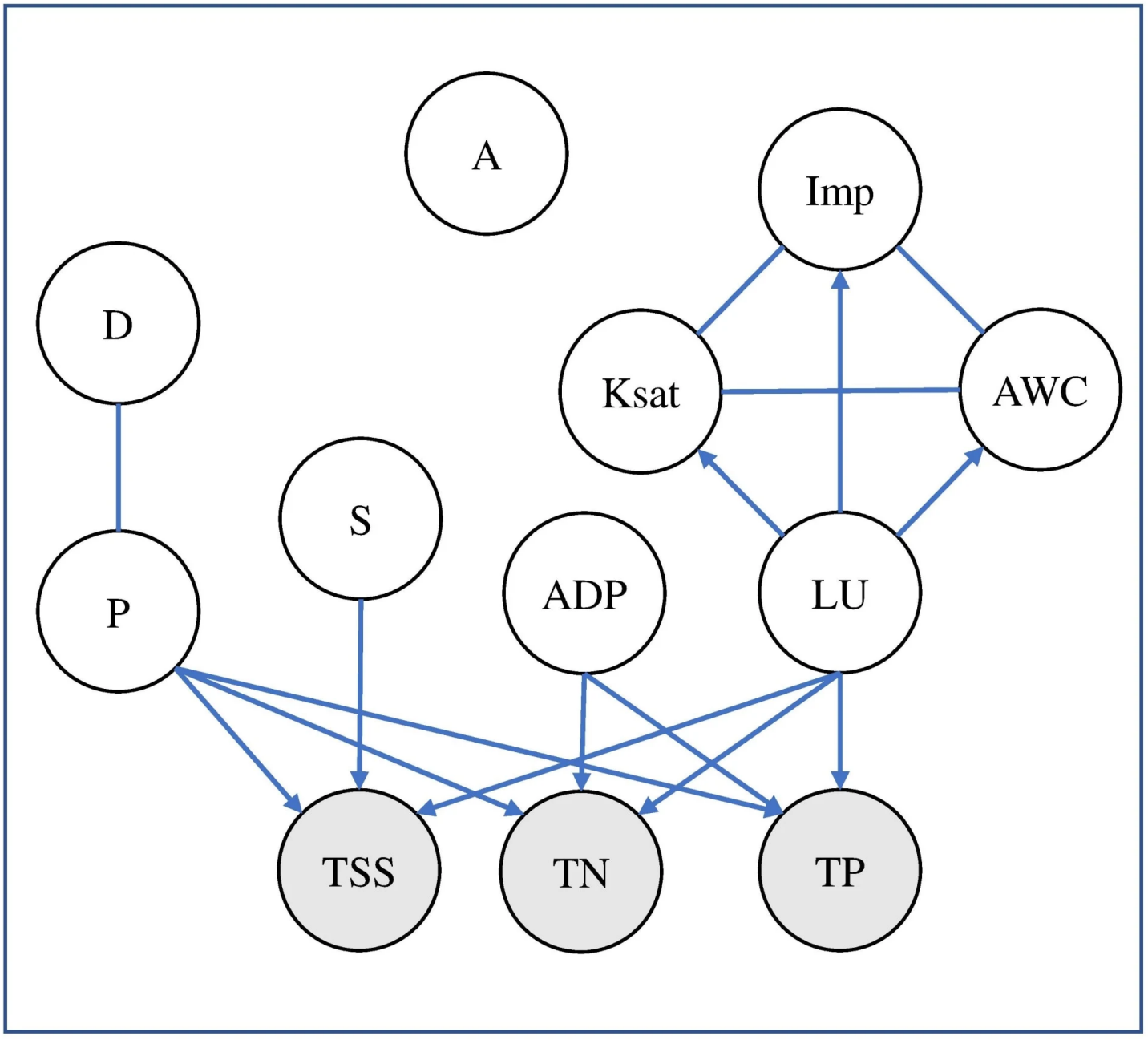


Figure 4. Synthesis figure informing relationships between climatological characteristics, catchment characteristics, and nutrients and sediment *EMCs.*

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We also would like to thank Computational Hydraulics International (CHI) for providing a university grant to use PCSWMM.

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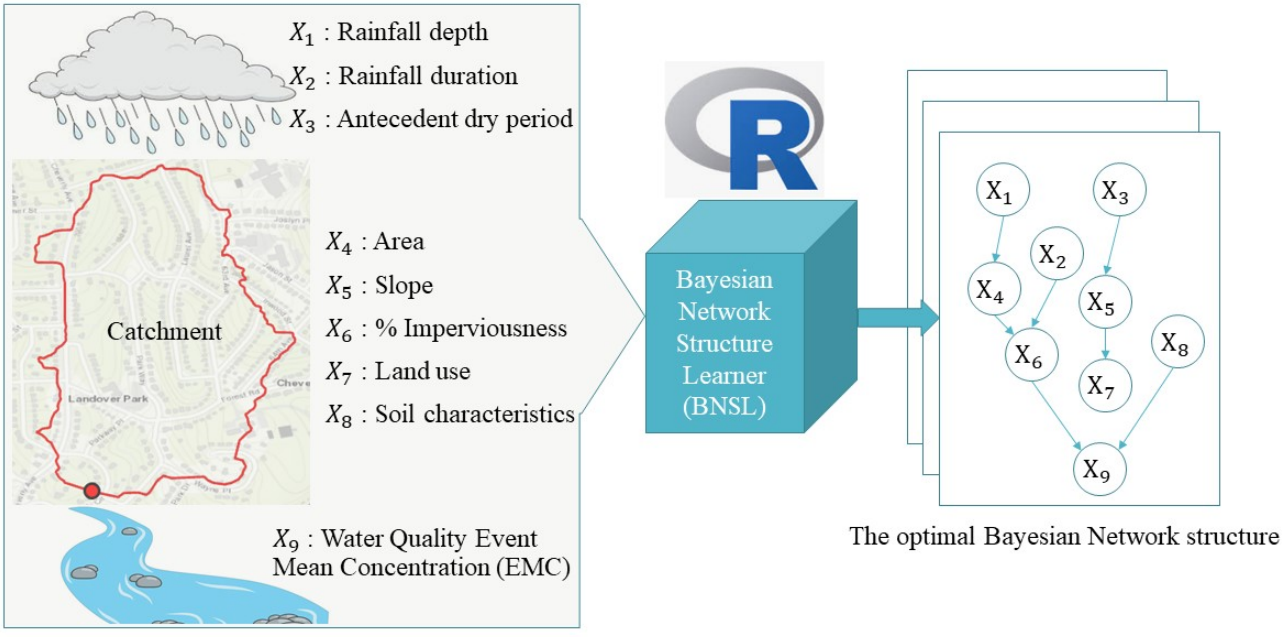
Mina is a PhD candidate in Biological Systems Engineering at Virginia Tech. She earned her M.S. in hydrology and water resources engineering from the State University of New York at Buffalo (UB) in 2018 and B.S. in civil and environmental engineering from the Sharif University of Technology (SUT) in 2016.

ABSTRACT

Urbanization increases runoff, sediment, and nutrient loadings to freshwaters, causing flooding, harmful algal blooms, and increased costs for drinking water filtration. Most watershed models use runoff quality data from specific land uses; coupled with a variety of methods for quantifying loads, the most common being Build-up and Wash-off (BUWO) equations for which loading is a function of antecedent dry period *(ADP)*. However, several studies have shown there is no significant correlation between urban runoff quality and *ADP*, suggesting predictions based solely on landuse and *ADP* are questionable. The objective of this study is to discover which parameters, climatological or catchment characteristics, are most significant and should be included in the BUWO relationship.

Stormwater quality data was obtained from the National Stormwater Quality Database (NSQD), which is the largest and most recent database of its type in the U.S. Bayesian Network Structure Learner (BNSL) was used to assess the relationships between catchment characteristics, climatological information, and runoff quality for each land use. Given the optimal BN structure, it was determined which parameters affect water quality event mean concentrations the most, and which the least. The results demonstrated that for some constituents (i.e. particulate nitrogen, particulate phosphorous, and sediments), other factors (such as rainfall depth and duration, surface slope) exert a more important influence on urban runoff quality than *ADP*.



The optimal Bayesian Network structure

(https://agu.confex.com/data/abstract/agu/fm21/2/7/Paper_917772_abstract_873607_0.jpg)

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