

Conceptualizing Pollutant Load Generation from Urban Catchments

Mina Shahed Behrouz^{1,1}, Mohammad Nayeb Yazdi^{2,2}, David Sample^{1,1}, and Durelle Scott^{1,1}

¹Virginia Polytechnic Institute and State University

²Department of Natural Resources Ohio

November 30, 2022

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.

Conceptualizing Pollutant Load Generation from Urban Catchments

Conceptualizing Pollutant Load Generation from Urban Catchments
Mina Shahed Behrouz¹, Mohammad Nayeb Yazdi², David J. Sample¹, & Durelle Scott¹
(1) Department of Biological Systems Engineering, Virginia Tech, VA; (2) School of Environment and Natural Resources, Ohio State University, OH

Introduction
Urbanization:
→ Increased impervious surfaces
→ Increased runoff
→ Increased transport of materials and sediment from urban catchments to downstream waterbodies.
Anthropogenic and natural algal blooms
→ As a result of increased nutrients and sediment concentrations in waterbodies.
We developed a model to predict the pollutant load from urban catchments.

Background
The National Water Quality Database (NWQD):
→ The largest data repository for streamwater quality in the U.S.
→ 2,000 water events from 200 homogeneous urban catchments.

Methodology
(1) Compilation of the existing information in the NWQD.
Chemological 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 PCSWAT software.
→ Digital Elevation Models (DEM) from the U.S. Department of Agriculture (USDA) National Resources Conservation Service (NRCS) Geospatial Data Gateway.
→ $Slope$:
→ National Land use Land Cover database (NLCD).
→ $Slope$ (S):
→ Digital Elevation Models (DEM).
→ $Soil$ data:
→ Available Water Capacity (AWC).
→ Saturated Hydraulic Conductivity (K_s).
→ Soil Survey Geographic Database (SSURGO) physical soil properties.

Results
Optimal Bayesian Network (BN) structures for materials and sediment.
Figure 3: The optimal BN structures for a) TP , b) TP , c) TP , and d) TP .
→ Bio-chemical and catchment characteristics affected materials and sediment EMCs.
→ P and D were related and affected TP , TP , and TP .
→ Among catchment characteristics, LU was the most influential factor.
→ LU affected AWC , K_s , and $Slope$.
→ Compared to other factors, the effect of ADP on TP was negligible.
→ Selected TP and TP is discussed in the text.

Discussion
Effect of Chemical and Catchment Characteristics on Materials and sediment EMCs.
 LU and ADP were not the only factors of having materials and sediment EMCs.

Acknowledgment
This study is primarily funded by grants supported by the Virginia Water Resources Research Center (VWRRC) grant number G21A000117 which is funded through the U.S. Geological Survey (USGS). Additional support was provided by the Virginia Agricultural Experiment Station and the Hatch program, Project 3-1000, of the National Institute of Food and Agriculture.
The authors express their appreciation to Drs. James R. Gries for his support in the U.S. Department of Agriculture (USDA) for his guidance and assistance.

This website uses cookies to ensure you get the best experience on our website. [Learn more](#)

Accept

Mina Shahed Behrouz¹, Mohammad Nayeb Yazdi², David J. Sample¹, & Durelle Scott¹

(1) Department of Biological Systems Engineering, Virginia Tech, VA; (2) School of Environment and Natural Resources, Ohio State University, OH



PRESENTED AT:

AGU FALL MEETING
New Orleans, LA & Online Everywhere
13-17 December 2021

Poster Gallery brought to you by
WILEY

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

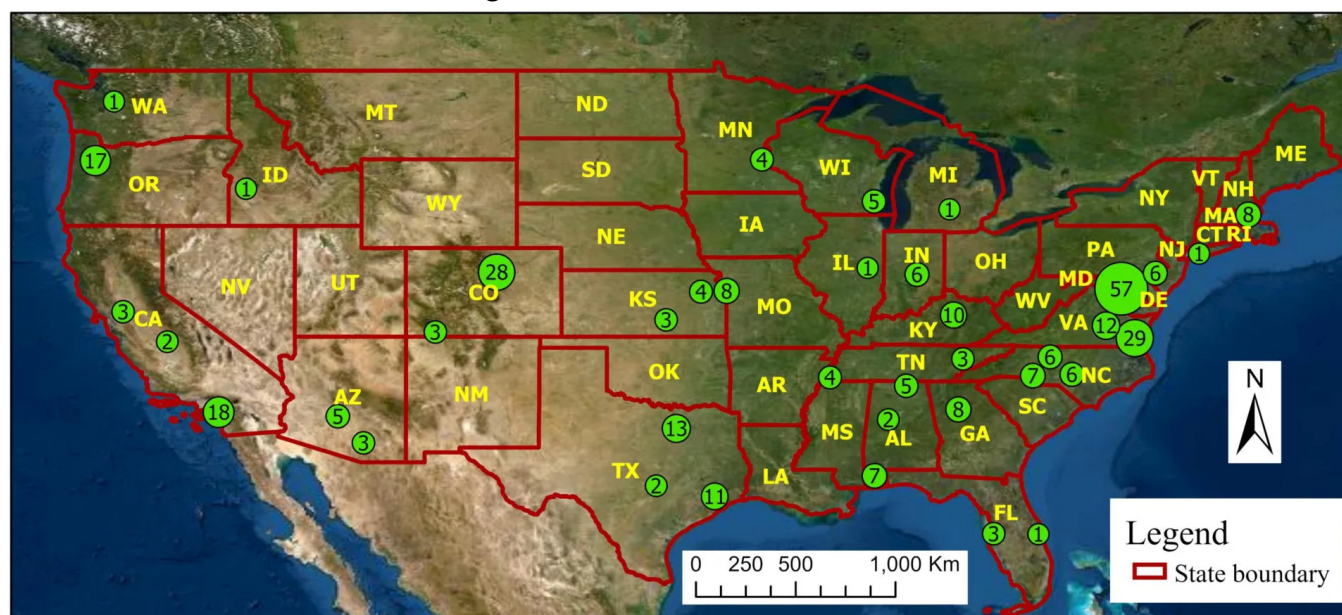


Figure 1. The number of monitoring locations with homogenous urban catchments in the NSQD.

- Water quality constituents:
 - Total Nitrogen (TN)
 - Total Kjeldahl Nitrogen (TKN)
 - Nitrate ($\text{NO}_3\text{-N}$) and Nitrite ($\text{NO}_2\text{-N}$)
 - 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

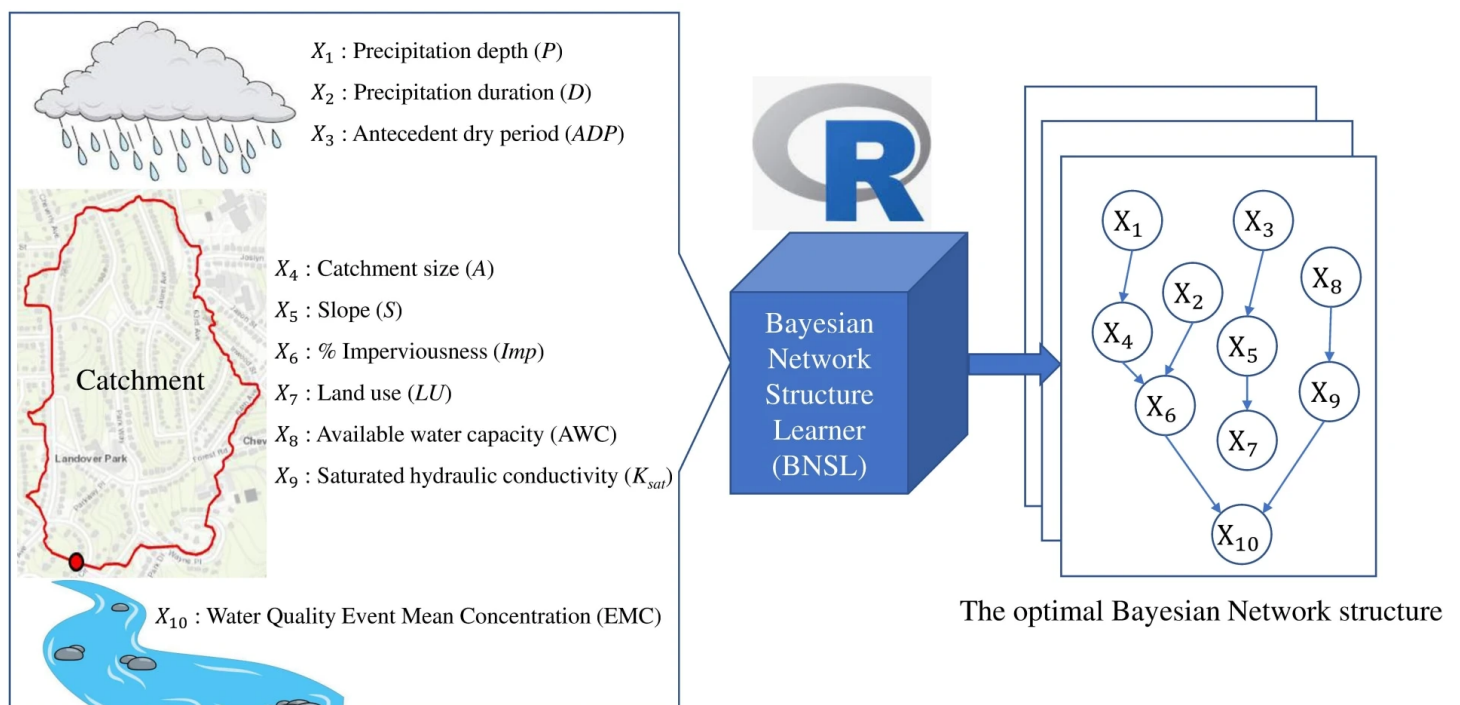


Figure 2. General overview of the methodology used in this study.**(2) Bayesian Network Structure Learner (BNSL):**

- 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:

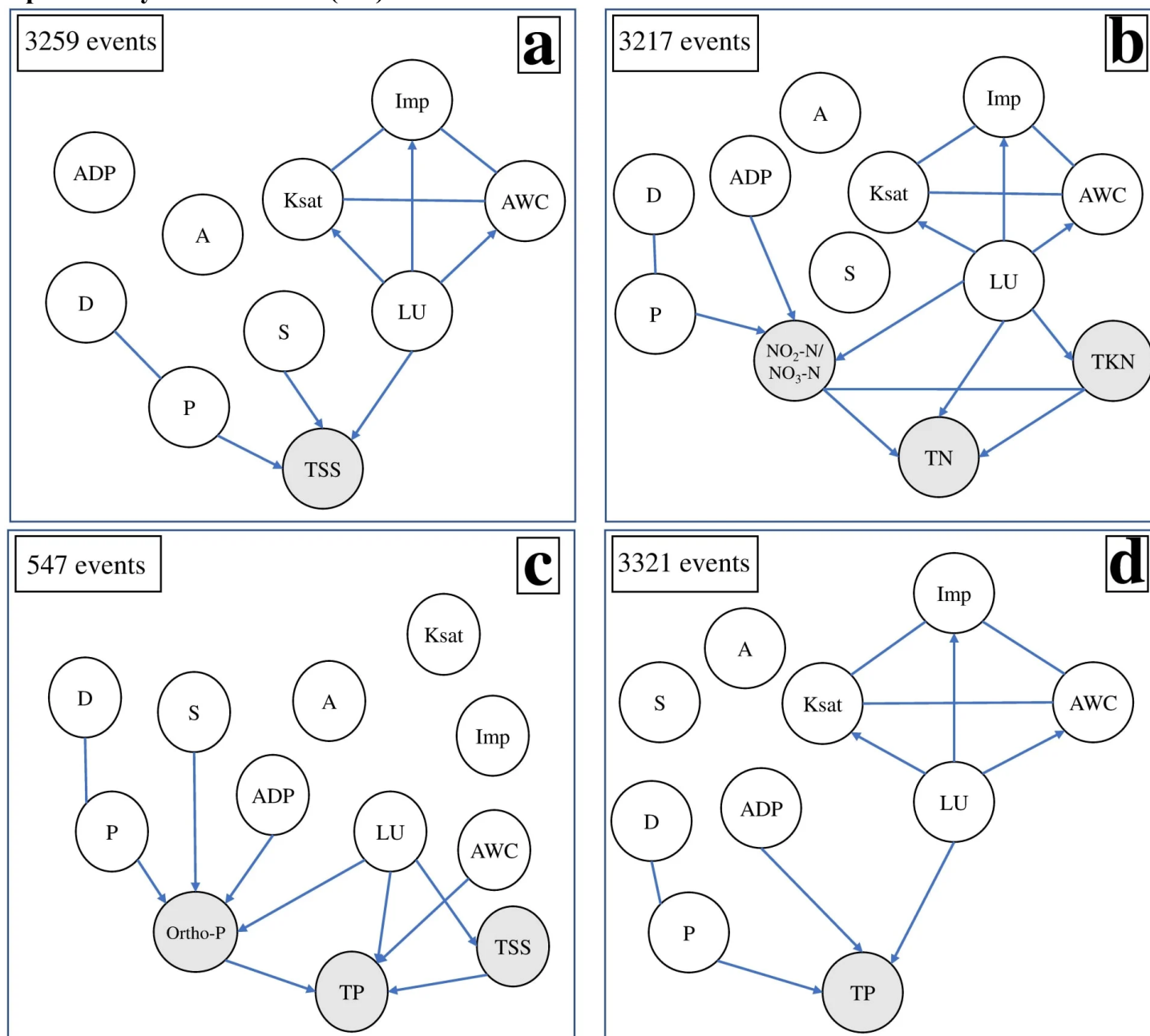


Figure 3. The optimal BN structures for a) TSS, b) TN, c) Ortho-P, and d) TP.

- 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*.

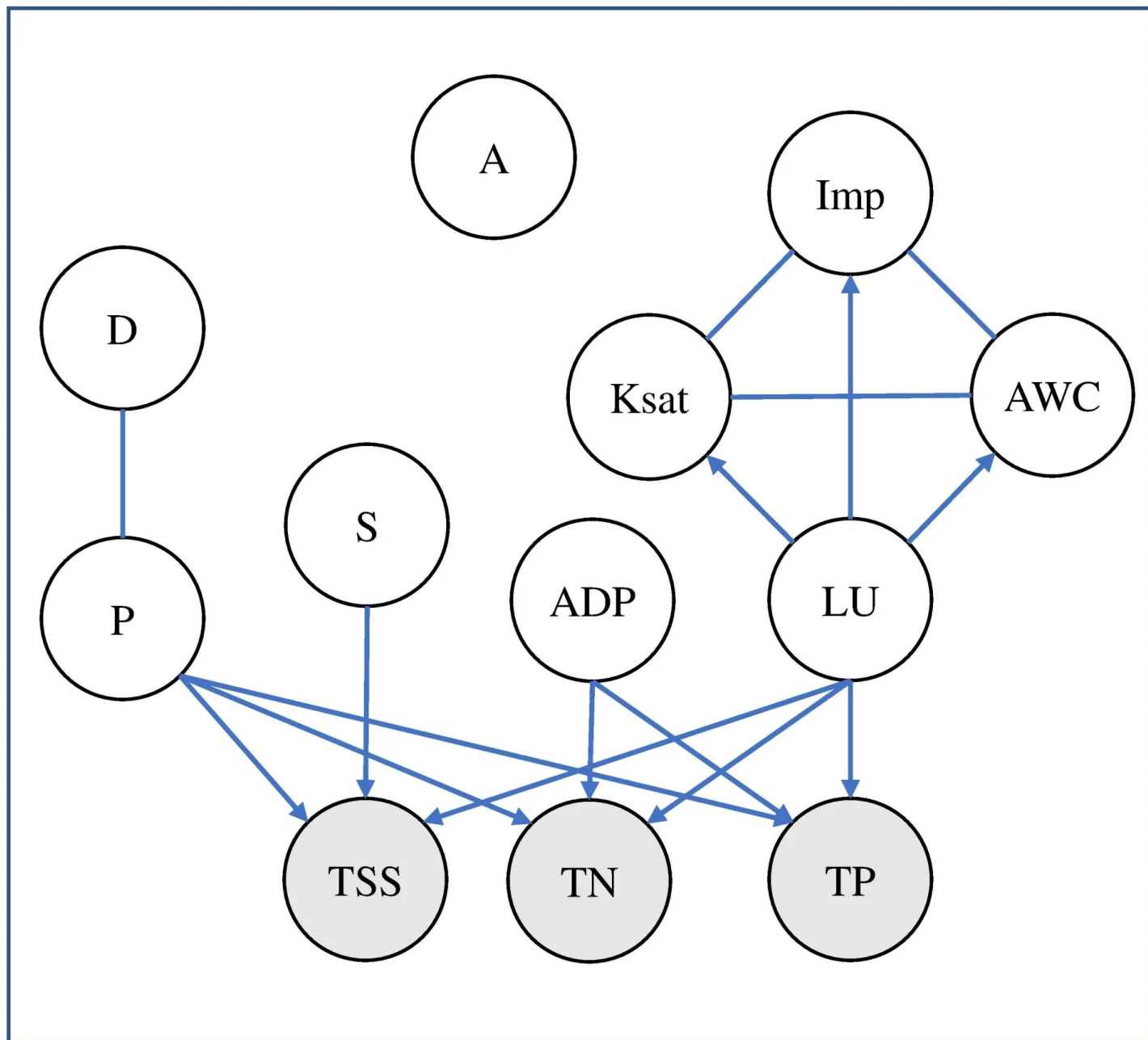


Figure 4. Synthesis figure informing relationships between climatological characteristics, catchment characteristics, and nutrients and sediment *EMCs*.

ACKNOWLEDGEMENT

This study is primarily based upon work supported by the Virginia Water Resources Research Center (VWRRC) grant number G21AS00517 which is funded through the U.S. Geological Survey (USGS). Additional support was provided by the Virginia Agricultural Experiment Station and the Hatch program, Project S1089, of the National Institute of Food and Agriculture.

The authors express their appreciation to Dr. James S. Owen Jr from the U.S. Department of Agriculture (USDA) for his guidance and assistant.

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

DESIGN YOUR IPOSTER

Background

Title Text Font

Textbox Title Color

insert image

remove image

Default



Title Text Color

Side Textbox Title Background Color

Fill Color

Subtitle Text Font

Textbox Text Font

Gradient Color

Default



Subtitle Text Color

Default



Side Textbox Text Color

OPEN Arrow Color

Side Textbox Background Color

Light Gray



Textbox Title Font

Middle Textbox Text Color

Default



Middle Textbox Background Color

reset all styles to default

Notice!

Your iPoster has now been unpublished and will not be displayed on the iPoster Gallery.

You need to publish it again if you want to be displayed.

You must be registered to publish your poster.

Please visit [service@agu.org \(https://www.agu.org/Fall-Meeting/Pages/Register-Housing/Registration-Rates\)](https://www.agu.org/Fall-Meeting/Pages/Register-Housing/Registration-Rates) to get registered. If you have recently registered, you may have to wait up to 10 minutes to be able to publish. If you are still unable to publish, please contact us at: [\[link\]](#)

Because of maintenance we have just saved your content and will within a few minutes logout all users and restart our server. We will be back in a moment.

Sorry for the inconvenience!

Because of maintenance we will within a few minutes restart our server. We will be back in a moment.

Sorry for the inconvenience!

LINK:

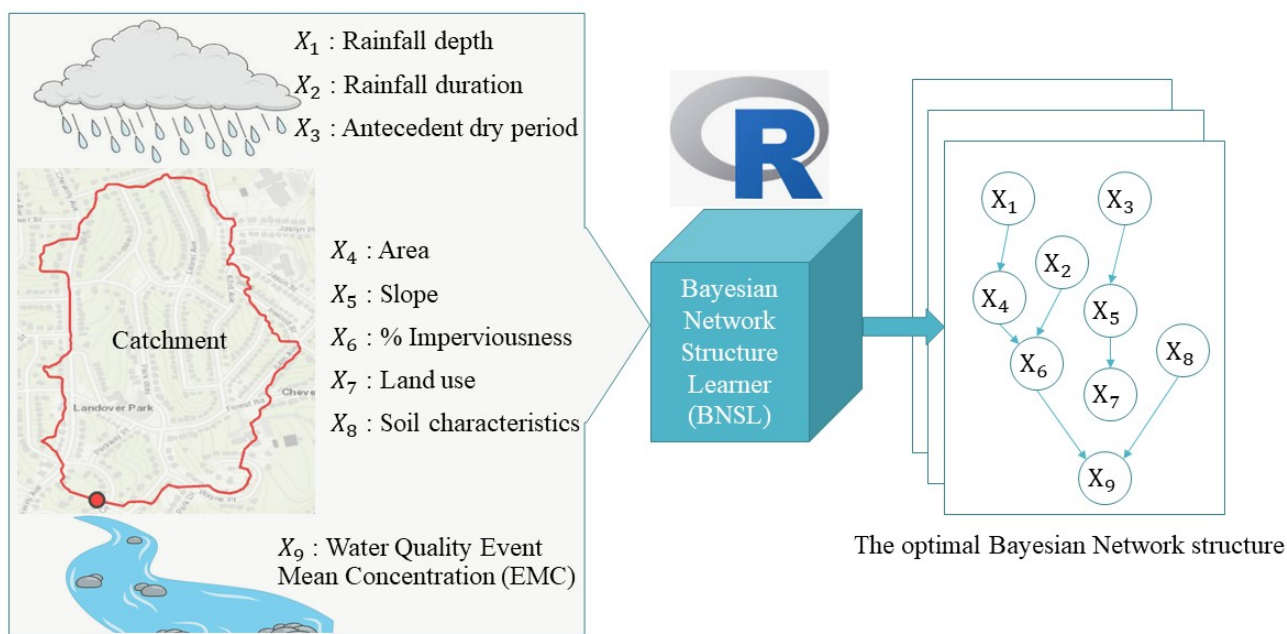
AUTHOR INFORMATION

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*.



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

CHAT SETTINGS

How it works

(https://ipostersessions.com/Schedule_chat_instructions_AGUFM/)

Choose Date & Time

Your Timezone

Time

From

To

Date

Please note: After setting up or changing your session time, it may take up to an hour for the change to be displayed on the Gallery screen.

Edit Chatroom Message

Hello

My chat will be starting at the time listed below. If the chat isn't open, it means I'm not here yet - so please contact me using the Contact Author button at the bottom of my iPoster.

Important: Participants will only be able to join your chat during the assigned time and when you have clicked the "Start Chat" button.

SAVE SETTINGS CANCEL

START CHAT

YOUR CHAT SESSION SCHEDULE

DateStart	End	Time zone	Actions	Add new session
-----------	-----	-----------	---------	-----------------

CHAT INFORMATION

IN PERSON POSTER HALL SESSION SETTINGS

How it works

(https://ipostersessions.com/poster_hall_presentation_session_instructions/)

Choose Date & Time

Your Timezone

Time

From

To

Date

Session - Board Number

Session - Board Number

Please note: After setting up or changing your session time, it may take up to an hour for the change to be displayed on the Gallery screen.

Edit Session Message

SAVE SETTINGS CANCEL

YOUR IN PERSON POSTER HALL SESSION SCHEDULE

Date	Start	End	Time zone	Actions	Add new session
------	-------	-----	-----------	---------	-----------------

SHARE POSTER

SHARE LINK:

Tweet

Shi

JOIN CHAT

In order to join Chat, please enter your name and email address

JOIN CHAT

AT MY POSTER

REVIEWER SURVEY



Upload new