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ESTIMATING NON-POINT SOURCE NUTRIENT LOADING IN THE QU'APPELLE AND SOUTH SASKATCHEWAN RIVER DRAINAGE AREAS IN THE CANADIAN PRAIRIES

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Excessive inputs of nutrients from non-point sources can lead to major negative impacts on water quality. It is therefore important to be able to identify the origin and quantify the transport of nutrients from non-point sources in order to prevent excess loading of receiving streams. Modelling of the transport of water and nutrients is made more difficult in the prairie region of Canada due to the relatively flat terrain and shallow wetlands known as potholes. The prairie pothole region is dominated by large non-contributing areas and internal drainage. This paper discusses a methodology to estimate non-point source nutrient loading in the Qu'Appelle and South Saskatchewan River drainage areas located in the prairie region of southern Saskatchewan, Canada (Fig. 1). The results of the study were used to determine annual export coefficients for Saskatchewan land uses and identify critical areas that contribute the most to nutrient loading.

The Soil and Water Assessment Tool or SWAT (Neitsch et al. 2009) was used to estimate the streamflow and nutrient loads of nitrogen and phosphorus in the watersheds. A digital elevation model, land use map, soil map, and daily temperature and precipitation data were required as input to the model. The digital elevation and land use data were obtained from GeoBase while the soil map and meteorological data were obtained from Agriculture and Agri-Food Canada's National Soil Database Soil Landscapes of Canada and Gridded Climate Dataset for Canada, respectively. The pothole hydrology was addressed by treating a portion of each sub-basin as draining to a pond as defined within SWAT. This allows for the percentage of the sub-watershed that is non-contributing to drain internally to the pond during dry periods and to the main river system during major events.

Calibration of the model hydrology was carried out in a representative watershed located in the Qu'Appelle River drainage using six years of measured streamflow data from Environment Canada's Hydrometric data station 05JK007. A model warm-up period of two years was used to stabilize the initial model parameter values. A manual calibration of snowmelt parameters was conducted followed by an auto-calibration of eight model parameters using the Parasol shuffle complex. Calibration of nutrient parameters was also performed using the Parasol shuffle complex auto-calibration. Eight parameters were selected and the calibration was performed using five years of water quality data from Government monitoring stations with a warm-up period of two years.

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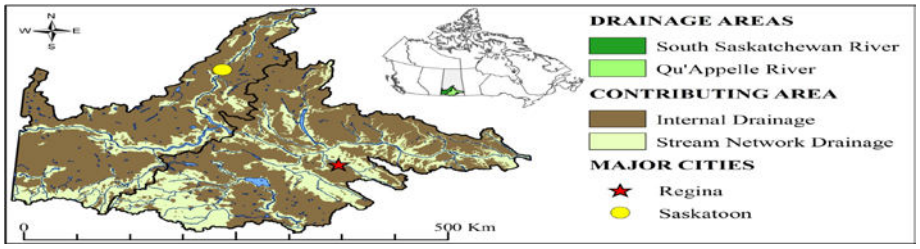

Figure 1 Contributing area in the study watersheds for a 1:2 year storm

Validation of the model hydrology was performed in a secondary representative watershed downstream of the first, also located in the Qu'Appelle River drainage area. The validation was conducted using five years of measured streamflow data from Environment Canada's Hydrometric data station 05JL001 with a warm-up period of two years. Results for the hydrological response simulation were found to have monthly Nash-Sutcliffe efficiency measures of above 0.8 for both the calibration and validation periods.

Using calibrated parameters the SWAT model was used to estimate nitrogen and phosphorus nutrient loading for the Qu'Appelle and South Saskatchewan River drainage areas for the 2000-2003 time period. The annual model results for total nitrogen (kg N/ha) and total phosphorus (kg P/ha) were used to determine export coefficient ranges for Saskatchewan land uses. While there exist a wide range of export values for any given land use in the United States, there is a lack of similar research in Canada. The results were compared to export coefficient ranges found in the literature for other watersheds in the Canadian prairie provinces of Manitoba and Alberta and for watersheds in the United States. The model results were then used to identify critical areas in the watersheds that contribute the most to nutrient loading.

The SWAT model was used to estimate non-point source nutrient loading in the prairie pothole region of southern Saskatchewan, Canada. The annual nutrient export coefficients determined for Saskatchewan prairie land uses were found to be comparable to similar export values provided for other prairie watersheds. The values were found to be in the low end of the literature ranges and this is thought to be due to the large amount of land that is non-contributing. Results from the study also show that the areas with the highest export of nutrient loads are located in the sub-watersheds that are adjacent to the river network. Due to the relatively flat terrain and extensive non-contributing areas these results are expected. It is recommended that efforts to reduce nutrient inputs in receiving streams be targeted to the riparian regions of the watershed.

REFERENCES

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