ISSN 1691-5402
ISBN 978-9984-44-070-5
Environment. Technology. Resources
Proceedings of the 8th International Scientific and Practical Conference. Volume 1

WATER QUALITY MODEL DESCRIPTION

Erika Ruskule
State Environmental Service Rezekne Regional Environmental Board
Zemnieku street 5, Rezekne, LV 4601, Latvia
Ph.: + (371) 64622597, fax: + (371) 64638215, e-mail: erika.ruskule@rezekne.vvd.gov.lv

Abstract. *Water wise use and conservation is one of the key prerequisites for economic sustainable development. Accession to the European Union, Latvia is committed to meeting the EU environmental requirements. Water Framework Directive (Directive 2000/60/EC, 2000) is a legal act, which provides water protection and sustainable management principles and tasks of the European Union. It provides uniform protection and management system for all waters: rivers, lakes, coastal waters and groundwater, providing that they must also achieve good water quality by 2015. year. The Directive provides for the identification of the current water situation and to obtain additional information by following the water monitoring and for basic background information to establish an action program to improve water quality. Therefore, the Latvian conditions are important to assess the flow of nutrients, their sources and amounts of Latvian detention basins using existing models and innovations in methods and model systems for the retention of part of the calculation. Therefore, in this publication are offered in various countries of the world models will be useful in Latvian processing of data.*

Keywords: *monitoring of water, nutrients flow, retention, calculation, mathematical modeling opportunities.*

Introduction

Geological structure, hydrogeological conditions, climate, land use character and intensity, as well as anthropogenic pollution levels Latvian significantly different from the situation in other countries. Latvian has been quite extensive and long-term studies of water chemistry and water structure analysis, however, these studies have been summarized and critically reviewed. Similarly, until now relatively little Latvian is used in mathematical modeling capabilities that allow analysis of the flow basin sub-basin level, and to identify human activity is causing pressure on surface water quality. In general, the concentration of nutrients in Latvian waters characterized by high turnover, which provides natural and anthropogenic factors interact. Of natural factors have significant effects of climatic conditions and hydrological regime variability, and biotic conditions in the development of a water body. Therefore, the Latvian conditions are important to assess the flow of nutrients, their sources and amounts of Latvian detention basins using existing models and innovations in methods and models of systems and nutrient retention of part of the calculation. To do this, it is necessary to study in Europe and the world of the models offered.

Materials and methods

Global assessment of nutrients loads are widely used modeling techniques which reflect existing knowledge about the emissions, flows and transformation processes in the catchment and water body. [1, 2, 8, 10] the large number of models provides a growing range of problems, and the fact that models typically are created for a particular catchment area or the region, where other models have not yet been applied. It should be noted that the models are diverse in their capabilities and limitations, so they must be carefully chosen. So far, Latvian diffuse or diffuse modeļing calculations used only a few studies (projects) to a defined catchment area or any part in the effective use of limited available data and the lack of research (especially in the last ten years), the model could be adapted to Latvian conditions. Therefore, in order to make calculations for the diffuse distribution of river basin districts, is used in the Helsinki Commission "loads to the Baltic Sea (HELCOM PLC) program following recommended methodology. [6; 7] It is worth noting - if not available the necessary data and calculations are make certain assumptions, the calculation result obtained approximate figures for the diffuse (mostly forest and farmland-related) and point source pollution in the percentage distribution of river basins. Since the currently lacks the necessary information and the lack of a separate study of the Latvian river basin and the resulting diffuse the results of calculations can be considered as estimates. Water quality models are powerful tools for effective water management and planning. Large number of models provides a growing range of problems, and the fact that conventional models are created for a particular catchment area or the region, where other models have not yet been applied.

Table 1.

Water quality models in Europe

Model name	Origin	European applications (Nation)	Purpose / Substances modelled	Process description
AGNPS	USDA; 1987	AUT, BE, CH, CZ, DE, DK, ESP, FI, FR, HU, IRL, IT, LTU, NL, POL, PRT, RUS, SVK, UK	nutrients, pesticides	conceptual
HBV-N	SMHI; 1994	SE, EST	eutrophication control / nitrogen transport	conceptual
INCA	Univ. of Reading; 1998	UK, FI, NO, DE, DK, NL, FR, ESP	eutrophication control / nitrogen transport	conceptual / mechanistic
MAGIC	Univ. of Virginia; 1985	UK, NO, DE, ESP, FI	acidification control / nitrogen transport	conceptual / mechanistic
MERLIN	Univ. of Virginia; 1997	UK, SE, NL, NO	acidification control / nitrogen transport	conceptual
MIKE SHE	DHI; 1993	BE, CH, DE, DK, CZ, ESP, FR, GR, HRV, HU, IT, LTH, NL, NO, POL, SVK, SLO, SE, UK, YU	eutrophication control / pollutant transport, nitrogen transport	mechanistic
SHETRAN	Univ. of Newcastle; 1996	UK, ESP, FR, IT, PRT	pollutant control / sediment and nitrogen transport	mechanistic
SMART	Wageningen UR; 1989	FI, NL, CZ, TUR, RUS, ESP, AUT	acidification control	mechanistic
SWAT	USDA; 1993	13 European countries e.g., IT, DE, UK, BE	eutrophication and pesticide control /sediment, nutrients,	conceptual

AGNPS (Agricultural Non-Point Source pollution model) - a model developed to examine the water quality as affected by soil erosion from agricultural and urban areas. AGNPS has three major components: hydrology, soil erosion and nutrient pollution.

HBV-N - simulate nitrogen leaching and transport through the groundwater, river and lake systems.

INCA (Integrated Nitrogen in Catchments) - Using the mass balance and reaction kinetics, INCA model composed of several sources of N and N of the principle of mechanism, including mineralization, immobilization, nitrification and denitrification.

MAGIC (Model of Acidification of Groundwater in Catchments) - a dynamic model of soil and water acidification can reconstruct and predict the catchment scale.

MERLIN (Model of Ecosystem Retention and Loss of Inorganic Nitrogen) - C and N cycle in ecosystems.

SHE (Système européen Hydrologique) - modeling system, which describes the main land hydrological cycle-flow processes. With regard to water quality modeling, SHE was first used in the modeling of nitrogen.
MIKE SHE - a dynamic simulation tool for analysis, planning and management, large water resources and environmental problems associated with surface water and groundwater, particularly where there is human intervention.
SMART (Simulation Model for Acidification's Regional Trends) - It is a simple soil acidification and nutrient cycle model that includes the main hydrological and biogeochemical processes.
SWAT (Soil and Water Assessment Tool) - There is a complex conceptual model. It is a continuous-time model, which operates daily during the period, the model is designed to control the impact of decisions on water, sediment, nutrient and pesticide yields with reasonable accuracy river basins. [4, 12, 13, 14, 15]

Table 2.

Water quality models for soil water and field scale in Europe

Model name	**Origin**	**European applications (Nation)**	**Purpose / Substances modelled**	**Process description**
ANIMO	Wageningen UR; 1991	BE, CH, DE, DK, CZ, FR, IT, NL, NO, POL, RUS, SLO, UK	nitrogen leaching to groundwater	mechanistic
EPIC	USDA; 1984	FR, DE, UK	soil erosion, nutrient cycling, pesticide fate, agricultural economics	conceptual
GLEAMS	USDA; 1987	FI, POL, DE, SE, RUS, UK, CZ	agricultural pollutants	conceptual
HYDRUS / SWMS	USDA; 1996	AUT, BE, DK, FR, DE, IT, NL, POR, ESP, SE, CH, UK	solute transport in porous media	mechanistic
MACRO	Swe. Univ. Agric.Scien.; 1994	SE, SP, DE, UK	solute transport in arable soils	mechanistic
PEARL	Alterra, NL; 2000	NL, SE, IT	pesticide leaching	conceptual / mechanistic
PRZM	US EPA; 1984	pesticide movement		mechanistic
SOILN	Swe. Univ. Agric.Scien.; 1987	SE, NO, FI, DK, EST	nitrogen leaching from arable soils	mechanistic
WAVE	Univ. Leuven; 1995	BE, NL, TUR	soil chemical transport	mechanistic

ANIMO (Agricultural Nitrogen Model) - dynamic model of carbon, nitrogen and phosphorus cycles, and saturated and unsaturated soil systems. This model has been developed for the analysis of nitrogen leaching from the soil surface, groundwater and surface water.
EPIC (Erosion- Productivity Impact Calculator) - This model has been developed to assess the impact of soil erosion on soil productivity.
Gleams (Groundwater Loading Effects of Agricultural Management Systems) - It has four major components: hydrology, erosion, sediment yield, pesticide transport, and nutrients.
HYDRO / SWMS - environmental modeling water flow analysis, and solute transport porous.
MACRO - The mathematical model of water flow and reactive solute transport in soil
PEARL (Pesticide Emission Assessment at Regional and Local scales) - have been used for pesticide registration procedure.

PRZM (Pesticide Root Zone Model) - This model consists of the hydrological (flow) and chemical components of transport channels to simulate the erosion, leaching, decay, etc.
SOILN (or Coupe Model) - Model description of nitrogen dynamics and losses in the soil profile of agricultural lands.
WAVE (Water and Agrochemicals in the Soil, Crop and Environment Lead) - describes a substance transport and energy transformations in the soil and the soil. [4, 5, 6, 9, 11]

Table 3.

Water quality models to groundwater in Europe

Model name	**Origin**	**European applications (Nation)**	**Purpose / Substances modelled**	**Process description**
ASM/ASMWIN	ETH; 1986	CH	pollution dispersion	mechanistic
MODFLOW/MT3D/RT3D	USGS; 1988	e.g. NL, DE, FR, IT, SE, UK	groundwater flow, solute transport	mechanistic

ASM / ASMWIN (Aquifer Simulation Model / for Windows) - is a horizontal or vertical, two-dimensional groundwater flow and transport model.
MODFLOW/MT3D/RT3D - is used to simulate the water supply system. [9, 13, 14, 15, 16, 17]

Table 4.

Water quality models for lakes in Europe

Model name	**Origin**	**European applications (Nation)**	**Purpose / Substances modelled**	**Process description**
DELWAQ-BLOOM-SWITCH (DBS)	RIZA; 1994	NL, Danube countries	eutrophication management	mechanistic
DYRESM	Centre for Water Research, University of Western Australia; 1980	BIH, FI, FR, DE, GR, IT, NL, NO, POL, PRT, ESP, SE, CH, TUR, UK	hydrodynamics and water quality in lakes and reservoirs	mechanistic
LIMNOD	Eldgenössische Technische Hochschule, Zürich, Switzerland; 1992	CH	lake management and scenario modelling	mechanistic
PC-LAKE (PCLOOS)	LWD; 1992	NL	eutrophication management	mechanistic
PH-ALA	Univ. of Rome, Italy; 1996 (?).	IT	eutrophication trend analysis	mechanistic

Table 5.

Water-quality samples of urban rainwater in Europe

Model name	**Origin**	**European applications (Nation)**	**Purpose / Substances modelled**	**Process description**
MOUSE	DHI; 1980's	distributed to all European countries, but unclear if used for water quality modelling	water quality and sediment transport modelling package for urban drainage systems, storm water sewers and sanitary sewers	mechanistic
SWMM	US EPA; 1970's	CZ, DK, FR, IT, ROM, ESP, SE, but unclear if used for water-quality modelling	all aspects of the urban hydrologic and quality cycles, including rainfall, snowmelt, surface and subsurface runoff, flow routing through drainage network, storage and treatment	mechanistic

Hydrology Models

MIKE model families. These are the Danish Hydraulic Institute (DHI) has developed physically reasonable models (MIKE 11, MIKE FLOOD, MIKE 21, MIKE Basin. Model operation requires a comprehensive and detailed information about the river basin.

HBV model

HBV model developed in the Swedish Meteorology and hydrology Institute (SMHI), 20th century 70 years old at the beginning, it was created by Professor S. Bergstrom. The model has many different variations. The advantage for the Nordic countries - it is believed that this pattern is best developed in the snow melting / formation scheme. Rain, snow, air temperature is used as raw data for calculating the water flow rate.

Channel general water can be described as follows:

$$P - E - Q = \frac{d}{dt}\left[SP + SM + UZ + LZ + lakes\right] \tag{1}$$

The various versions of the HBV model has been applied in over 40 countries worldwide. It is suitable for countries with so different climatic conditions, such as Sweden, Zimbabwe, India and Colombia. HBV can be used as a semi-distributed model. Each area is divided into zones according to altitude, lake area and vegetation. The model is usually open every day for rainfall and temperature calculation, as well as daily and monthly estimates of potential evaporation. Model is used for flood forecasting in the Nordic countries, and many other purposes such as flood modeling, water resources assessment collection, nutrient load calculation.

Input data are observations of precipitation, air temperature and estimates of potential evapotranspiration. For example, proposed in the literature: [5, 13]

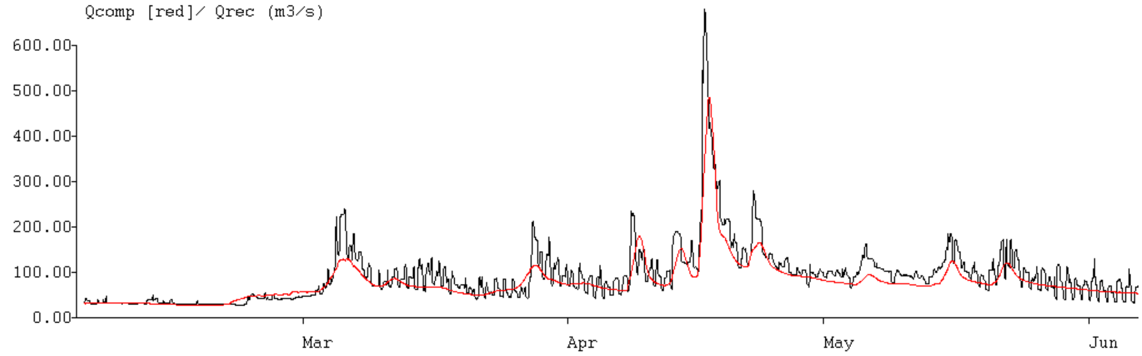

Figure 1. **Obtained (Qrec) and calculated (Ocomp) A comparison of data at 1 hour of inundation model**

SWAT model

The model aims to: provide for and determine the impact of economic activities on water quality, provide for the consequences of various business-to-water, sediment, certain nutrients, pesticides and large quantities of N in closed basins. In studies using data on weather conditions, surface runoff, flow, infiltration, ET, transmission losses, pond and reservoir location, grain yield and irrigation, groundwater flow, nutrient and pesticide use, water movement. [17]

Fyris model

There was the 1996th in Sweden to determine the characteristic of river nutrients (nitrogen and phosphorus) pollution load distribution, and retention (retention) factor FRYS river in central Sweden. Since the case of river basins divided into homogeneous fractional basins, which represent the hydrochemical monitoring of water quality measurement points.

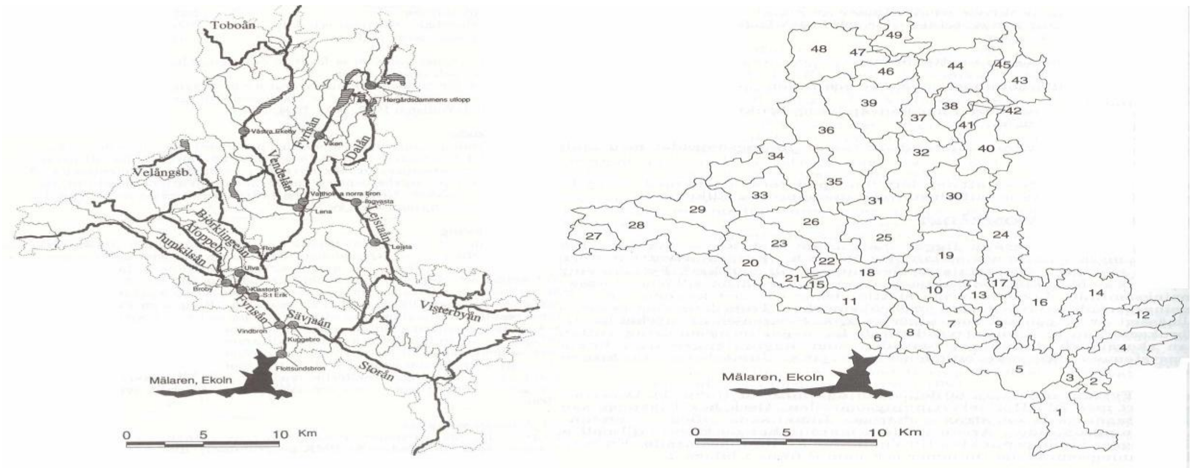

Figure 2. **River basin fractional basins** [15]

Results and analysis

Loads of biogenic elements and flow of the assessment can be used for statistical and dynamic models. Statistical models based on regression analysis, for example, between the observed concentrations of nutrients and water flow rate, or between the observed nutrients loads and catchment characteristics. Dynamic model conceptually describes the physical, chemical and biological processes in the catchment and water and nutrients simulate load and water flow rate. Dynamic models can be used for water quality forecasting purposes. [3] From the HELCOM PLC guidelines, for a given river basin in diffuse or diffuse pollution discharged to surface waters from the mainland, Latvian at the expense of two ways: (1) where it is monitored in all diffuse and point source pollution load of the river basin, the result can be calculated by the river load (2) if the monitored river and separate the diffuse and point sources of pollution of the river basin. In my opinion, would be applicable in Latvia HBV model for nutrient load calculation [6].

METQ model

Latvian since the late 80th years of groundwater regime and runoff mathematical modeling is used in conceptual models and METUL METQ family. On the input data used in daily meteorological observations. So far, the model is successfully calibrated for both large (the Daugava, Salaca), although some small river basins. Develops over time METQ model, it has been several versions (METQ96, METQ98, METQ2005, METQ2006). Model is the latest version of METQ2007BDOPT with semi-automatic calibration feature. It is possible to calibrate a conceptual model METQ2007BDOPT with different values describing the pool surface climatic and geomorphologic conditions Latvian river basins, which have been terminated or will continue to hydrologic comments Model METQ a conceptual mathematical model with the use of variable sites (distributed) parameters. METQ conceptual model has the following user options: ground and surface water runoff (including runoff transformation) estimates of snow accumulation and melt modeling. Using this model, it is possible to calculate hydrological variables - the average daily flow rate. Of the simulated and observed flow rate reproducibility indices have been adopted by the statistical criterion R2, correlation coefficient r and the average permanent drainage basin. River District runoff process model representing the four main calculations: snow formation and ablation, the active soil layer balance, ground water and the inside layer of the balance sheet as well as runoff transformation parts of the basin drainage network. River basin or parts of the basin a space less than 2000 km2, which is not large lake or broad flood plain with a large pop-regulating capacity, can be considered as linear hydrological system and the relationship between the output can be described by linear differential equations with concentrated or fixed parameters. Conversely, if the lake basin, the drainage basin of such a transformation is calculated with the hydraulic methods. In Mode total runoff is characterized by the following components - surface runoff (Q1) and groundwater runoff, which in turn divided into the upper layer of groundwater runoff (Q2) and the lower layer groundwater runoff (Q3). Surface runoff can be divided into two groups depending on the underlying frameworks: infiltration excess runoff, or Horton runoff: soil saturation runoff, which occurs when the soil is saturated with water to land surface. In Model METQ2007BDOPT is divided up into three different types of water collections: collections of moisture in the snow, Stocks soil moisture on the active layer moisture and groundwater stocks capillary-off layer. [6 7]

Summary

Latvian circumstances, it is important to assess the flow of nutrients, their sources and amounts of detention basins, using existing models and innovations in methods and model systems for the retention of part of the calculation. Therefore, in this publication are offered in various countries of the world models will be useful in Latvian processing of data and approbation.

References

1. Arheimer B., Brandt M. (1998) Modelling nitrogen transport and retention in the catchments of southern Sweden. *Ambio* 27(6), 471-480.
2. Clark M.J., Cresser M.S., Smart R., Chapman P.J., Edwards A.C. (2004) The influence of catchment characteristics on the seasonality of carbon and nitrogen species concentrations in upland rivers of Northern Scotland. *Biogeochemistry* 68, 1-19.
3. Grimvall A., Stalnacke P. (1996) Statistical methods for source apportionment of riverine loads of pollutants. *Environmetrics* 7, 201-213.

4. Helsel D.R., Hirsch R.M. (1992) Statistical methods in water resources. Amsterdam: Elsevier Science Publ. B.V.
5. Iital A., Stalnacke P., Deelstra J., Loigu E., Pihlak M. (2005) Effects on large-scale changes in emissions on nutrient concentrations in Estonian rivers in the Lake Peipsi drainage basin. *J. Hydro*l. 304, 261-273.
6. Jansons V. (2005) Lauksaimniecības noteču monitorings. LLU tēma Nr.13/04 L-105.
7. Kļaviņš M., Rodinovs V., Kokorīte I. (2002) Chemistry of Surface Waters in Latvia. Rīga:LU, 286 pp.
8. Petersen W., Bertino L., Callies U., Zorita E. (2001) Process identification by principal component analysis of river water-quality data. *Ecol.Model.* 138, 193-213 26
9. Rantakari M., Kortelainen P., Vuorenmaa J., Mannio J., Forsius M. (2004) Finnish lake survey: the role of catchment attributes in determining nitrogen, phosphorus, and organic carbon concentrations. *Water, Air, Soil Pollut.: Focus* 4, 683-699.
10. Shrestha S., Kazama F. (2006) Assessment of surface water quality using mulitivariate statistical techniques: A case study of the Fuji river basin, Japan. *Environ.Modell.Softw. (in press)*
11. Stalnacke P., Vandsemb S.M., Vassiljev A., Grimvall A., Jolankai G. (2004) Changes in nutrient levels in some Eastern European rivers in response to large-scale changes in agriculture. *Water, Sci. Technol.* 49, 30-36.
12. Vassiljev A., Stalnacke P. 2003. Statistical modelling of riverine nutrient sources in the Lake Peipsi drainage basin. Diffuse pollution conference proceedings, Dublin, 41-46.
13. http://iopscience.iop.org/1755-1315/4/1/012004/pdf/ees8_4_012004.pdf
14. http://www.meteo.lv/upload_file/Udens%20kvalitates%20modelesanas%20sistema%20Lielupes%20upju%20baseina%20apgabalam.pdf
15. http://kalme.daba.lv/faili/materiali/LU_Zin_konference/Prezentacijas%20LU65KONF/AbramenkoK_LegzdinsA.pdf
16. www2.llu.lv/homepg/lif/konf/kagm.ppt
17. www2.llu.lv/homepg/lif/konf/vj.pdf