Journal of Environmental Studies
Vol. 46, No. 2, Summer 2020
Journal Homepage: www.Jes.ut.ac.ir
Print ISSN: 1025-8620 Online ISSN 2345-6922

# Modeling of Flow Hydrodynamics and Biological Oxygen Demand Changes in the Wetlands (Case Study: The GoleNilofar Wetland, Babol, Iran)

**Parand Bamdadi, Ozeair Abessi*, Hasan Amini-Rad**

Department of Environmental Engineering, School of Civil Engineering, Babol Noshirvani University of Technology, Babol , Iran

DOI: 10.22059/JES.2021.308980.1008065

**Document Type**
Research Paper

**Received**
January 28, 2020

**Accepted**
April 16, 2020

## Abstract

Due to particular ecological proprties and high resistance time, wetlands are able to refine surface waters by their natural purification potential, hence, they are often referred to as “Earth’s kidneys”. In the current study, to investigate the purification function of the wetlands an ecological model has developed using MIKE3 and the ECOLab madual of DHI for the Babol Golenilofar watland. The computer model of wetland has developed using the field data of meteorological records and the quantitative and qualitative data of inflow. In the end, a senario of the real case has been developed for the season of spring. Based on our modeling results for this season, the wetland could absorve the pollutants and clean it up partially, where the influx of BOD (5.5 mg/l) has droped to 4.7 and 3 mg/l in the outflows for pond 1 and 2 as a result of 18 to 24 days of resistance and the biochemical processes of the wetland. The prediction of the model found to be close enough to our field observations.

**Keywords:** Biological oxygen demand, Hydrodynamic of flow, Natural treatment, Wetland

* Corresponding author Email: oabessi@nit.ac.ir

**Extended abstract**

**Introduction**

Among surface water resources, wetlands have special importance in providing habitat for various plant and animal species due to their ecological roles. Wetlands are swampy areas, reservoirs, and natural and man-made ponds that have static or flowing water, fresh or saline, permanent or temporary. One of the most important but little known traits of wetlands is to improve surface water quality. These systems can provide effective treatment for a variety of contaminants in the water, hence they are known as "natural water purifiers". Removal of pollutants occurs by the effect of simultaneous operation of physical, chemical, and biological processes including deposition, filtration, chemical reduction, adsorption, biodegradation, photo-oxidation, consumption by animals and plants, etc. The mechanisms and interdependencies between the ecological components of the wetland are complex and many of them are not yet fully understood.

With the development of technology and the use of computers in engineering processes, the use of computer models to simulate ecological processes in natural ecosystems has become very common during the last years. Therefore, making an appropriate hydrodynamic model of the water body with the ability to simulate the affecting processes for the fate and transmission of the pollutant, has become a technical necessity.

So far, several field studies and computer simulations have been reported to evaluate the efficiency of the wetlands to improve water quality under the predicted load of pollution entering the wetlands. The experience of using mathematical models for the simulation of the wetlands has shown the high ability of these models for the simulation of the complex ecological processes. So, the computer models have seriously been considered as a modern tool for the management of wetlands and improving its purification efficiency.

**Materials and Methods**

In the current study, the experiences of Babol city in the province of Mazandaran for the planning of a city wetland i.e. GoleNilofar wetland, to the common space is reported. The hydraulic retention times in wetland different basins are about 20 to 60 days. The inflow to the wetland is not changing along the seasons and was measured about 0.153 $m^3/s$ in spring, 0.157 $m^3/s$ in summer, 0.273 in fall and 0.217 $m^3/s$ in winter

In this study, the computer model of the GoleNilofar wetland is developed using Hydrodynamic and ECOLab modules of the MIKE3 software. The FM hydrodynamic model is a basic numerical model for the flow simulation in MIKE3 that can be used in all water bodies i.e. the wetlands, rivers, bays, coastal waters, and open oceans. This model can simulate the flow unsteady three-dimensional features in the conditions of density changes in the environment. The model can simulate the impacts of external forces including meteorological and tidal parameters. The EcoLab module of MIKE software was developed as a modeling tool to investigate the effects of natural aeration, sunlight photooxidation, and sedimentation together with the plants and bacterial uptakes on the fate of organic matter and purification capability of the different water bodies. In the simulations, only BOD (Biochemical Oxygen Demand) time variations and spatial changes in the wetland were investigated. The amount of oxygen needed by microorganisms for the oxidation of degradable materials within 5 days is called $BOD_5$ i.e. 5-day biological oxygen demand. Biological oxygen demand is one of the most important indicators of water pollution. Water contamination is caused by external material in a suspended or dissolved form that changes the physical, chemical, and biological properties of water.

Discussion of results

The BOD of the inflow was measured by sampling the incoming current in different seasons along 1398 (2019-2020). The BOD together with the discharge flow rate, temperature, and density of the water are modeling inputs that are required for the simulation. Here in this paper, the results of the

wetland ecological simulations have been reported for the season of the spring. This season is selected as it is the beginning of a growing season in the wetland. To better investigate the distribution of pollutants and the changes in the flow properties, the water body of the wetland is assumed to be stationary and the concentration of BOD is considered equal to zero at the beginning of the simulation. So, the inflow to the wetland (to the pond 1) was measured 0.153 $m^3/s$ and the BOD of incoming water was measured 5.5 mg/l, both of which did not change significantly during the spring. The time interval of 3 hours and the number of steps of 735, equivalent to one whole season is introduced to the model. Finally, the simulation results at the end of spring were compared with the observed values from the field sampling at the beginning of summer.

As a result of hydrodynamic modeling when the wind speed is at its maximum during the season, i.e. 9 m/s, the flow velocity in the wetland is also at its maximum. For wind speeds of 9 m/s, the velocity of the surface flow was above 0.37 m/s, which due to the closed boundaries of the environment, lead to deep current and material conduction to water depth. Ecological modeling exhibited that due to the chemical and biological processes, as well as the long retention time of the pollution in the wetland, distancing from the entrance, the BOD decreases clearly. According to the discharge flow rate and volume of each pond, the retention time in the first pond is about 18 days, in the second pond 24 days, and the third pond 73 days. The results also showed that the amount of BOD entering the wetland (5.5 mg/l) at the end of spring and early summer reaches 4.7 mg/l at output 1 and about 3 mg/l at output 2. The field measurements of BOD at the beginning of summer in both outlets showed the values of 4 and 3.4 mg/l, respectively. Comparison of the modeling results with our field observation at the end of this season exhibited that the model can predict the BOD concentration with 80% accuracy without adjusting the coefficients and only using the values reported for similar conditions in previous studies.

**Conclusions**

In this work, an ecological model has developed using the ECOLab module of MIKE3 for the Gole-Niloufar wetland which is an urban wetland in the city of Babol, north of Iran. The cpability of the wetland to improve the quality of incoming water has been discussed. This waterbody is a valuable natural resource in the region in terms of entertainment and recreation and has been used to supply water to rice farms downstream. In the developed model, the wetland is simulated during the spring for 93 days with 735 of 3-hour time steps in which the actual data of the inflow and BOD have been utilized. The BOD parameter was selected as an indicator of contamination to the organic matters and the process of transfer, diffusion, and decomposition were investigated by hydrodynamics modeling of the flow and the simulation of the BOD degradation in the wetland. The calculated values were compared with the field measurements at the end of the season and the accuracy of the model was investigated. A comparative study of the results with the field data exhibited that the model can predict the degradation of BOD concentration in the ponds. The results of this study showed that due to the high retention time, low flow rate, and the natural rehabilitation and purification, this wetland can reduce pollution to a desirable level. It has also been observed that the water quality of the wetland depends on the physical, chemical, and biological processes of wetland beside the properties of the incoming water. So, improving the wetland performances from this perspective can ensure the safe use of water downstream.