ISSN 2541-223X
Volume 4 2022

RIVER WATER QUALITY MODELING BASED ON DO AND BOD PARAMATERS USING QUAL2KW SOFTWARE (CASE STUDY : WINONGO RIVER, SPECIAL REGION OF YOGYAKARTA)

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ABSTRACT
The location of the study was on the 46.93 km Winongo River which passes through the Sleman Regency, Yogyakarta City, and ends in Bantul Regency. The Winongo River receives sources of pollutants such as domestic waste, agricultural waste, and fishery waste so river pollution occurs. The purpose of this study is to analyze the water quality of the Winongo River with point source and nonpoint source pollutant sources and obtain alternative strategies for Winongo river water quality management from the results of Qual2kw modeling simulations that can increase DO concentration and reduce BOD concentration. Based on the results of the study showed that the occurrence of pollution in the Winongo River, as evidenced by the average BOD concentration that exceeded the class II quality standard of 4.45 mg / L and the concentration of 5.38 mg / L. Simulation results of pollutant load modification and local oxygenation simulations were effective in increasing DO concentrations in the Winongo River. Meanwhile, the simulation of local oxygenation and simulation of modification of pollutant loads are effective in reducing BOD concentrations in the Winongo River.

Keywords : River Water; DO and BOD Parameters; Software

1. INTRODUCTION

Rivers are water resources that are utilized by humans so they must be maintained so that pollution does not occur in rivers. However, the reality is that the amount of liquid waste discharged into rivers is increasing, causing river pollution and a decrease in river water quality (Saily and Haniza, 2020). The decline in water quality of the Winongo River is caused by point source and non-point source pollutants derived from domestic waste, drainage channels, fishery waste, and agricultural waste. So that this study used BOD and DO water pollutant parameters that can represent water quality conditions in the Winongo River. Based on the results of river water quality monitoring carried out by the DLH of DIY Province in 2020 showed that the condition of the Winongo River water quality is declining this evidenced by the concentration of BOD that has exceeded the class II water quality standard of 4.31 mg / L.

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DOI: https://doi.org/10.20885/icsbe.vol2.art13

River water sampling can describe river water quality more accurately but takes a long time and high costs. So river modeling is carried out that aims to minimize the cost of observation and time. The proper modeling to simplify the water quality conditions of the river is the Qual2kw model. The Qual2kw model is modern modeling that can simulate and simplify the condition of river water quality presented in graphic form. Modeling Qual2kw is one dimensional, steady flow water quality model, and useful even in data limited conditions (Hossain *et al,* 2014). Qual2kw models can simulate a number of components such as water temperature, pH, BOD, DO, organic nitrogen, ammonia, nitrite and nitrate , total nitrogen, total phosphorus, phytoplankton and bottom algae (Kannel *et al, 2007)*. The advantage of Qual2kw software is that it is easier to use in simulating water quality with input from pollutants using trial and error but this Qual2kw cannot simulate heavy metal parameters (Pelletier, 2006). So that the results of the simulation of the application of Qual2kw will be obtained river management strategies in reducing the burden of polluters (Zolfagharipoor and Ahmadi, 2016). Another supporting aspect in the selection of modeling Qual2kw method because Qual2kw has a validation value that is good enough to represent the quality of river water (Rezagama *et al*, 2019). The purpose of this study is to analyze water quality with point source and non-point source pollutants on BOD and DO parameters in the Winongo River and obtain alternative strategies for managing winongo river water quality from the results of Qual2kw modeling simulations that can increase DO concentration and reduce BOD concentration.

2. METHODOLOGY

2.1 Time and Location the Research

The research location is in the Winongo River of DIY Province along the upper reaches to the lower reaches of the Winongo River. The 46.93 km Long Winongo River flows through Sleman Regency, Yogyakarta City, and Bantul Regency. Sampling was carried out at eight sampling points using the grab sample method.

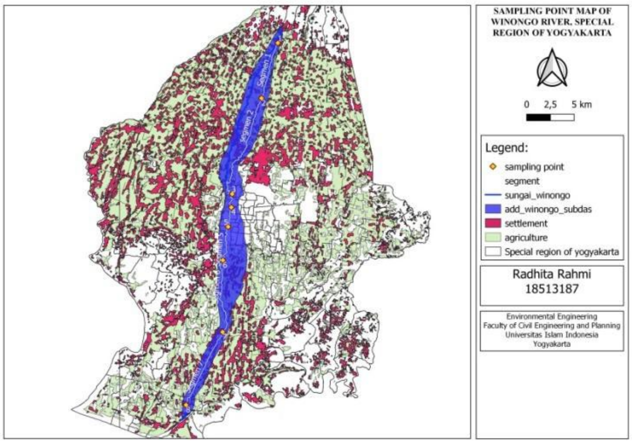

Figure 1. Figure Sampling Points Map Winongo River

Table 1. Winongo river sampling points

Points	Location	coordinate
Point 1	Purwobinangun, Pakem, Sleman	Lat -7.631592 Long 110.399742
Point 2	Denggung, Donokerto, Sleman	Lat -7.659041 Long 110.383255
Point 3	Jatimulyo, Kricak, Yogyakarta	Lat -7.776609 Long 110.356011

ISSN 2541-223X
Volume 4 2022

Point 4	Jlagaran, Bumijo, Yogyakarta	Lat -7.789838 Long 110.356560
Point 5	Tamansari, Wirobrajan, Yogyakarta	Lat -7.808202 Long 110.353629
Point 6	Dongkelan, Kasihan, Bantul	Lat -7.840225 Long 110.348602
Point 7	Bakulan, Jetis, Bantul	Lat -7.908928 Long 110.348317
Point 8	Gading, Kretek, Bantul	Lat -7. 978733 Long 110.313395

2.2 Field Obserations and River Segmentation

The purpose of field observation is to find out the state of the Winongo River to get an idea of how the environment and problems around the Winongo River are direct. Meanwhile, the purpose of river segmentations is to facilitate the division of activities around the Winongo River. This makes it easier to identify the source of pollutants. Sources of pollutants contained in the Winongo River are point source (tributaries, fishery channels and drainage channels) and non-point sources (agricultural waste, domestic waste and fishery waste). The following is an overview of the source of the Winongo River pollutants in figure 1**.**

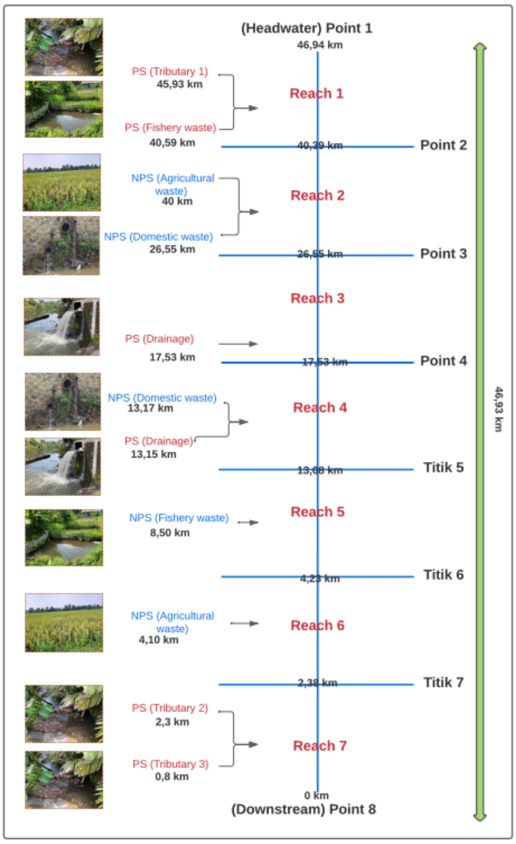

Figure 2. Figure of Winongo river pollutans source

2.3 Data Analisys Using Qual2kw Software

Winongo water quality modeling using Qual2kw software version 5.1 starts from inputting the data obtained at the time of sampling. Input data such as worksheet reach, worksheet headwater, worksheet climatology, worksheet point source, worksheet non-point source, worksheet hydraulic data, worksheet temperature data, and worksheets WQ data.

2.3.1 Calibration Model

Calibration of data on the Qual2kw method to at the formation of models. Calibration is the stage of determining the most suitable coefficient value so that the comparison of the model results with the data in the field shows the most statistically excellent values (Marlina *et al,* 2017). Calibration of model formation is carried out using trial and error and running the program repeatedly so that a model this is close to the actual condition or in the field is obtained. Based on the research of Fajaruddin (2017), calibration for river discharge data uses a trial and error process by changing the incoming discharge and discharge that comes out on the point source and non-point source worksheets while for the calibration of water quality data, it changes the do and BOD concentrations of polluting sources on the point source and non-point source worksheets and changes the n manning value on the reach worksheet.

2.3.2 Validation Model

Model validation aims to measure the error value of the model data with field data. Validation model must be done because there is a variability of data at different times (Fatmawati *et al,* 2012). Validation is carried out by calculating the error value using RPD (*Relative Percentage Difference)* method. RPD is an equation used to evaluate calibration and validation in the Qual2kw model on river water parameter data. If the resulting error value is < 25%, then the model can be accepted [9]. The formula equation of the RPD method is:

$$RPD = \frac{Csim - Cobs}{Cobs} \; x \; 100\%$$

2.3.3 Simulation Model

After the model is received using RPD methods, a model simulation is then carried out which aims to get an overview of the object according to several conditions. In this study, three model development scenarios were carried out as follows:

1. Modification of polluting load (scenario 1)
2. A ddition of discharge (scenario 2)
3. Local oxygenation (scenario 3)

The selection of the 3 scenarios is based on research conducted by Mustafa et al (2017) which shows that the scenario of modification of pollutant loads and local oxygenation is effective in increasing DO concentrations in the Diyala River, Iraq (Mustafa *et al,* 2017), as well as the absence of research in Indonesia on river modeling using these scenarios.

3. RESULT AND DISCUSSION

3.1 Hydraulic Condition Of the Winongo River

Winongo River hydraulic data is data that will be input into the Qual2kw software. Such hydraulic data is required for the calibration process in Qual2kw modeling. Hydraulic data are obtained from direct measurements at the time of sampling.

ISSN 2541-223X
Volume 4 2022

Table 2. Winongo River Hydraulic Data

Points	Flow (m3/s)	Depth (m)	Velocity (m/s)
Point 1	0,28	0,42	0,25
Point 2	0,64	0,4	0,36
Point 3	9,03	0,66	1,2
Point 4	4,83	0,46	0,5
Point 5	3,33	1,15	0,13
Point 6	5,1	0,31	1,5
Point 7	8,46	2,35	0,24
Point 8	5,38	1,73	0,17

3.2 Water Quality Condition Of the Winongo River

Winongo river water quality data obtained from sampling, field measurements and laboratory tests.

Table 3. Winongo River Water Quality Data

Parameter	Unit	Quality Standards	Results							
			Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8
Water Temperature	°C	3°C	24	25	27	25	25	26	27	27
pH		6 - 8,5	7,3	7,7	7,6	7,5	7,5	5,8	7,4	7,12
Flow	m3/s		0,28	0,64	9,03	4,83	3,33	5,1	8,46	5,38
DO	mg/L	5	6,5	5,5	5,8	6	4,2	5,3	4,9	4,9
BOD	mg/L	3	3,28	4,28	4,5	3,9	4,76	4,8	4,95	5,15

3.3 Winongo River Water Quality Modeling Using Qual2kw

3.3.1 Calibration and Validation Results

Model calibration is carried out using trial and error and running programs repeatedly so that a model that is close to real conditions. DO concentration in this modeling is influenced by the hydraulic conditions of the river, air temperature, water temperature, and effluent entering the Winongo river (Q. S. Chen *et al,* 2018). After the model graph approaches the field data, it then performs model validation which aims to calculate the model error value using the RPD method. Based on calculations using the RPD method, an error value was obtained for debit data of 11%, DO data of 14%, and BOD data of 3%.

This is following the condition if the calculation result is < 25%, then the model can be accepted

3.3.1 Model Simulation Results

Simulation Model Scenario 1

Modifictaion of the the pollutant load in the simulation model scenario 1 is to reduce the value of the source of pollutants entering the Winongo River at a BOD concentration of 20% on the point source worksheet and non-point source (Kanell *et al,* 2007).

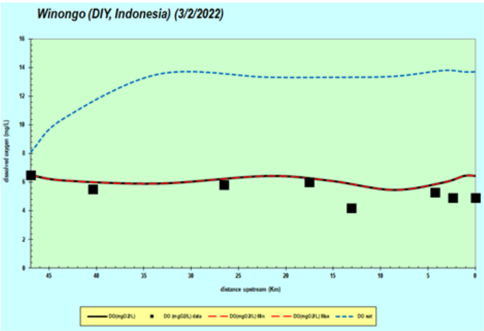

Figure 3. Simulation 1 results DO parameter

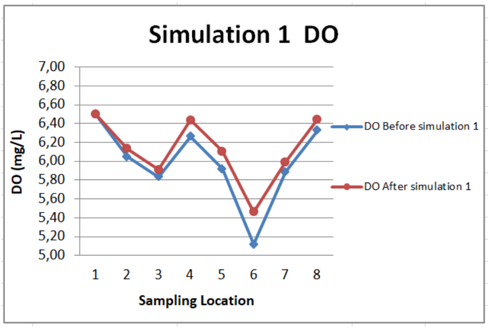

Figure 4. Comparison before and after simulation 1

The modeling results showed that the simulation of the scenario 1 model was effective in increasing the concentration of DO on the Winongo River. Figure 3 shows an increase in DO concentration at all sampling points. It happens because in scenario 1 it is done by reducing the concentration of the source of pollutants in the BOD parameter by 20%. So that the effluent input was reduced by 20% which caused the BOD concentration on the Winongo River to also decrease.

When the BOD concentration decreases, there is an increase in the concentration of DO in the river. It can occur because the BOD concentration decreases, signaling a decrease in the amount of oxygen used by microorganisms to degrade contaminants, so the amount of oxygen available in the Winongo River can increase. The higher the DO concentration indicates water is in better condition (Rahmandani *et al,* 2021)

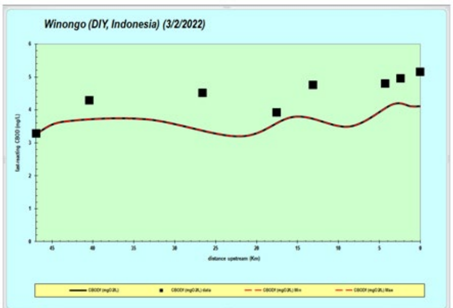

Figure 5. Simulation 1 results BOD parameter

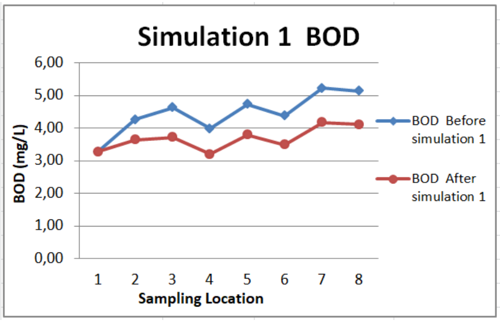

Figure 6. Comparison before and after simulation 1

Based on figure 5 shows that the simulation results of the scenario 1 model are effective in reducing BOD concentrations in the Winongo River. There is a comparison of BOD values before and after scenario in figure 6 which shows a decrease in BOD concentrations at all sampling points. This is because scenario 1 is carried out by reducing the concentration of pollutant sources in the BOD parameter by 20%. So the effluent input is reduced by 20% which causes the concentration of BOD in the source of pollutants to also decrease. When the BOD concentration decreases, it indicates a decrease in the value of the BOD concentration from polluting sources such as agricultural waste, fishery waste, domestic waste, and others. Decrease in the concentration of BOD is characterized by a decrease in the amount of oxygen used by microorganisms to degrade contaminants.

Simulation Model Scenario 2

The addition of discharge in the simulation model scenario 2 was carried out by a combination of modification of the polluting load and using a high discharge in the upper reaches of the river. The discharge is input in the headwater worksheet of the discharge data section. Before the discharge scenario, the headwater at the input was 0.28 m3/s then when the scenario was carried out using the highest discharge, which was 9.03 m3/s. The purpose of this additional discharge is to find out how effective the use of high discharge is against the increase in DO and decrease in BOD on the Winongo River.

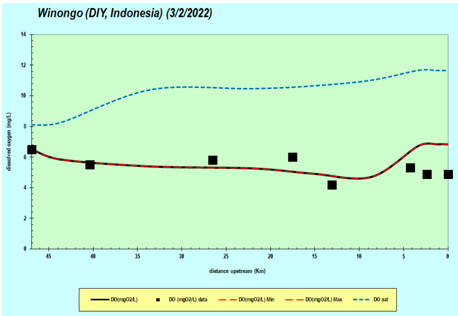

Figure 7. Simulation 2 results DO parameter

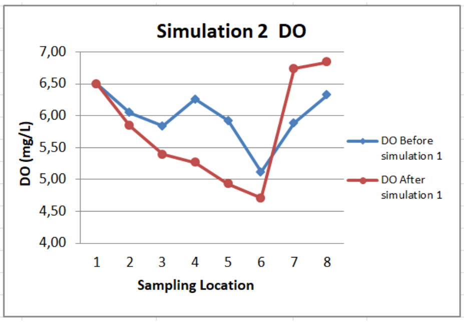

Figure 8. Comparison before and after simulation 2

The decrease in DO concentrations is caused by the value of n manning in this modeling exceeding 0.04. Based on the research of Gholipour et al (2015), the value of n manning greater than 0.04 can reduce the concentration value in each parameter including this DO parameter. Although in scenario 2 there was also a 20% decrease in the source of pollutants in the BOD parameter, this could not increase the do concentration in the river. It can be concluded that the simulation of the scenario 2 model was ineffective in increasing the concentration of DO on the Winongo River. But when combining the modification of the polluting load and the addition of discharge and placement of the plunge, this scenario 2 can increase the do concentration in the river, this can be seen in the changes that occur at point 7 and point 8 due to the fall after point 6. The same is true of research conducted by Mustafa et al (2017) on the Diyala River, Iraq.

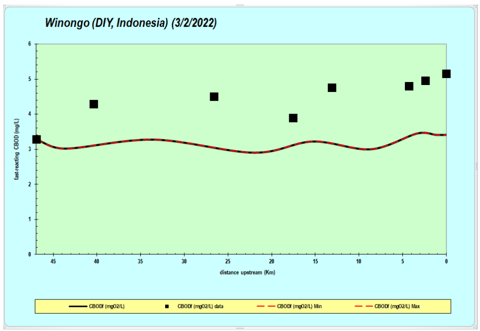

Figure 9. Simulation 2 results BOD parameter

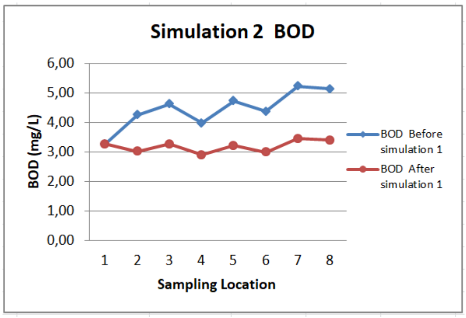

Figure 10. Comparison before and after simulation 2

Based on figure 9, it shows that the use of scenario 2 is effective in lowering the concentration of BOD on the Winongo River. BOD concentrations may decrease because in scenario 2 this also decrease 20% of pollutant sources in BOD parameters and the use of high discharge by 9.03 mg / L at headwater greatly affects the decrease in BOD concentrations in the Winongo River. The addition of discharge in the upper reaches of the river causes decrease in the BOD concentration due to the dilution of the pollutant source so that the burden of pollutants is reduced (Rezagama *et al,* 2019).

Simulation Model Scenario 3

The simulation model of scenario 3 is local oxygenation. This local oxygenation effect can occur when there is a plunge in a river [14] .In scenario 3, it assumes the placement of a plunge (h = 1 meter) at a sampling point whose DO concentration is low, namely point 5. So input the weir data on the reach worksheet. Scenario 3 aims to find out how effective the plunge is against an increase in DO and a decrease in BOD on the Winongo River.

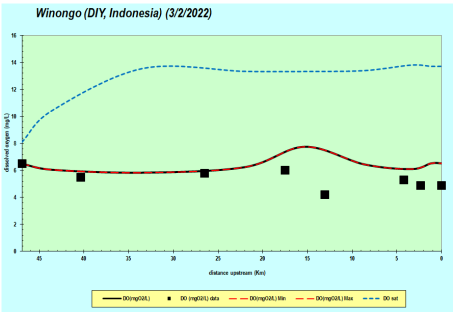

Figure 11. Simulation 2 results DO parameter

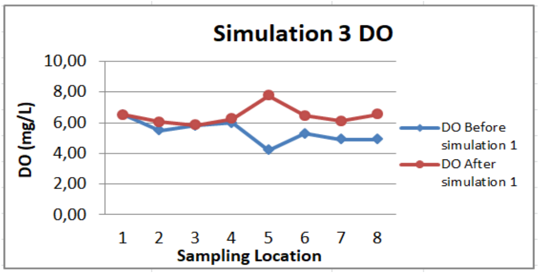

Figure 12. Comparison before and after simulation 2

Based on Figure 11 shows that the simulation results using local oxygenation scenarios are effective in increasing DO concentrations at the physical point. The critical point is at point 5 with an actual DO concentration of 4.2 mg / L. The placement of the plunge causes a difference so that scientific aeration occurs. Figure 12 shows a comparison of DO concentrations before and after the simulation, which clearly shows the change at point 5. Simulation result was obtained that at a critical point (point 5), there was an increase in DO concentration which was initially 4.2 mg/L to 7.76 mg/L. It is influenced by the placement of the plunge which can cause aeration to produce a local oxygenation effect (Dyah *et al,* 2013). So it can be concluded that scenario 3 is effective in increasing the concentration of DO on the Winongo River.

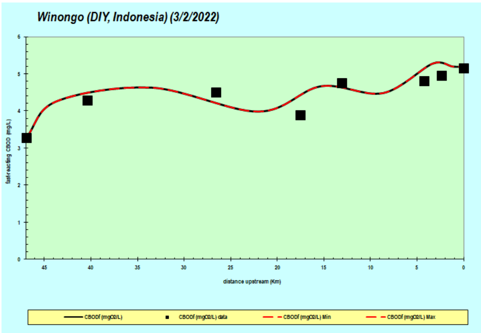

Figure 13. Simulation 2 results BOD parameter

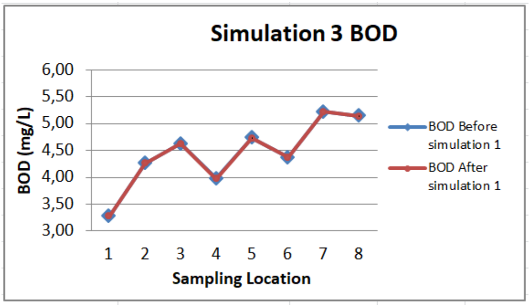

Figure 14. Comparison before and after simulation 2

Based on figure 14 shows that the absence of a change in concentration occurred in the BOD concentration using a local oxygenation scenario. The placement of the plunge at the critical point does not affect the concentration of BOD at Point 5 or on the Winongo River. This is because the BOD decay rate in this segment has been optimized so that it does not provide changes to the BOD concentration with the placement of the plunge (Nugraha, 2007). The high burden of pollution entering the river can interfere with the river's ability to recover itself and reduce river water quality.

3.4 Winongo River Water Quality Management Strategy

Based on the results of the study, it is find that the condition of the polluted Winongo River as evidenced by the concentration of BOD and DO had exceeded the predetermined quality standards. So that an alternative to winongo river water management is needed by:

1. Placement of the plunge at the critical point of the river. Placing the plunge, so that there is a decrease in elevation which causes scientific aeration and has the potential to degrade BOD pollutants. It also increases the concentration of DO in river water because of the plunge of water contact with air. So that the river can make self-purification efforts (Rezagama *et al,* 2019).
2. The decrease in the concentration of pollutant sources can be done by building communal WWTP along the Winongo River in every district in DIY Province. So that the wastewater management in the WWTP is expected to reduce the burden of pollutants before entering the Winongo River which can reduce the concentration of BOD.

4. CONCLUSION

Based on field measurements, laboratories and modeling showed that the polluted Winongo River was proven at BOD concentrations exceeding the class II quality standard of 4.45 mg / L. Results of simulated contaminant load modification and local oxygenation simulations were effective in increasing DO concentrations and the results of simulated discharge additions and simulated contaminant load modifications were effective in reducing BOD concentrations in the Winongo River.

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