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The Numerical Modeling of Petrochemical Wastes Spread in Asaluyeh Port and Presenting Solutions to Limit the Spread

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Abstract: *Asaluyeh port, a special economic zone in terms of oil and gas in South Pars, is located on the Persian Gulf coasts. After establishing this special economic zone, unknown and congenital ailments have become quite frequent among the residents of the zone. These ailments result from the pollution produced by industrial facilities, which, in terms of the level of pollution, are unmatched throughout the world. One of these pollutions has to do with petrochemical wastes. Petrochemical wastes are one of the factors polluting the seas. Given the important point that this type of pollution will directly affect the existing ecosystems in the sea, we need to try our hardest to reduce and control such pollutions. Released petrochemical wastes are considered a severe threat to water and sea environments that affect the level of resources and a wide spectrum of organisms entangled with this complex food chain, including humans. The present study utilizes MIKE 21 to simulate the governing two-dimensional currents in the zone numerically. It then analyzes how petrochemical wastes are released and spread in Asaluyeh port during summer and winter. Eventually, using the model, it is suggested that environmental factors such as waves, and ebb and flow, guide the wastes to the coasts. In the final section, some solutions are presented to prevent this spread.*

Key Words: *Asaluyeh port, pollution, petrochemical wastes, MIKE 21, two-dimensional current, wave, ebb and flow*.

1. INTRODUCTION:

Asaluyeh Port is the capital of Bushehr County in the south of Iran and the shore of the Persian Gulf Coast. This special economic zone extends from Pars Energy to the Southern Pars Gas region in the middle of the Persian Gulf. After establishing this special economic zone, due to the pollution caused by industrial facilities that result in an unprecedented amount of pollution in the air, unknown and congenital diseases have broken out among the babies and the residents of this zone.

An instance of such pollution would be the pollution resulting from petrochemical wastes. Petrochemical wastes have enjoyed particular international significance both politically and economically, and this is due to the observable and observed effects arising from releasing petrochemical wastes on beaches and seas. The pollution resulting from petrochemical wastes in the seas is not just a local problem, and the consequences can extend to international scales. The existence of such wastes in the sea can leave adverse effects on both the sea life and the economy of the communities, especially in the coastal areas. The released petrochemical wastes are considered a serious threat to the water and sea environment, affecting the level of resources and a wide range of organisms related to a complex food chain. These petrochemicals can damage the seas in various ways, including physical destruction that directly affects the wildlife and their habitats (such as damage to the skin of birds or sea mammals). Also, the toxicity of petrochemicals chemicals alone can poison the organisms and destroy them. The intensity of the released petrochemicals depends on various factors such as the physical attributes of the petrochemical wastes, the type of petrochemicals, and the natural actions of the water stream (wave, flow, and ebb).

One of the most primary factors contributing to the stable development of petrochemical industries is the optimum use of resources. Furthermore, given the increasing importance of water, the reusing of wastewaters is also of great significance since water plays such an essential role in the sustenance of life. Conducting studies on the simulation of the release and spread of petrochemical wastes plays an essential role in planning and presenting plans for preparing against accidents and critical situations such as the entry of significant levels of petrochemical wastes into the seas by refineries. Finding a model for the release of petrochemical wastes affected by various hydrodynamic parameters constitutes the most important and necessary challenge in preventing the spread of such pollutions. Since MIKE 21 is a specialized software and simulator in the hydrodynamics of the seas, it can be used for conducting ethnicity research. The data are entered, the appropriate fixed coefficients are calculated, and the stream of water, waves, and eventually, how pollution is spread can be appropriately modeled. In 2012, Salehipour et al. [35] modeled oil stains and compared the movement path of oil stains under different types of winds in the Persian Gulf. In 2013, Tajik et al. [36] studied the spread of oil pollutions in the coastal sediments (a case study of Bushehr County). Alipour et al. [37] studied the corrosions in oil tankers and presented some guidelines for reducing the environmental effects of oil leaks in 2013. In 2014, Pashaei et al. [38] studied the cases of oil leaks in the ecosystem of the Persian Gulf and their effect on the biota and flora of the region. Qiasi et al. [39] numerically simulated the oil pollution in northwestern coasts of the Persian Gulf. Rangzan and Abidavi [40] studied oil pollution in the seas and the oceans by using remote sensing technology in 2015. Zhu et al. [44] conducted a study in 2015 focused on modeling the oil pollution along the beaches of the Bohai sea. In a study in 2017, Nishinu and Imanu [47] presented some promoted calculations for the simulation of conflagrations caused by oil pollution during tsunamis. Abscal et al. [50] modeled the movement path of oil stains in 2017 using high-frequency radar flows (a case of northwestern Europe). Zhang [54] modeled oil pollution in Newfoundland in 2017. However, the present study seeks to provide a solution for controlling and preventing the expansion of pollutions caused by petrochemical wastes and, consequently, help preserve the ecosystem of the Persian Gulf. Furthermore, it seeks to facilitate the planning and development of some plans to better prepare against accidents and critical situations such as the expansion of pollutions caused by petrochemical wastes.

2. METHODOLOGY:

In the current study, the studies are divided into general and local; consequently, it was necessary to introduce the area under investigation in two different modes: (1) general: concerned with the Persian Gulf, and (2) local: concerned with Assaluyeh Port.

Releasing petrochemical wastes in seas is affected by such hydrodynamic conditions as waves and currents. Therefore, before the numerical simulation of the release of petrochemical wastes, it is necessary to simulate the waves and currents so that a calibrated model is provided as the producer of the factors effective in transferring and releasing oil.

Simulating sea phenomena such as waves, currents, and transferring and releasing oil stains requires a set of data including the position of shoreline, depthometric information, water level, information on the condition of the winds, waves, the temperature of water surface, and also information on oil and oil products in the zone. Given the point that the accuracy of the final results is directly dependent upon the accuracy of the input, all different types of data required for conducting the modeling task are presented in the following section. To study how petrochemical wastes are spread in the sea environment, the contaminating sources should be identified and categorized in terms of amount, condition, and physical and chemical compounds. Ten stations releasing petrochemical wastes during February, as the cold season, and June, as the hot season, are measured. The information on the situation of the stations, the release status, and the level of existing contaminants are presented in tables 1 and 2.

Table 1. The geographical coordinates of coastal (sea) stations for sampling the wastes

No.	**Refinery/petrochemistry**	**Stations info**	**Station code**	**Geographical coordinates of the Cartesian system**	
				E	**N**

1	The first and second refineries	Beach, phases 1, 2, and 3	STB-01	655117.09	3044601.39
2	The third refinery	Beach, phases 4 and 5	STB-02	653270.00	3046448.00
3	The fourth refinery	Beach, phases 6, 7, and 8	STB-03	654838.00	3045138.00
4	The fifth, sixth, and seventh refineries	Beach, phases 9-10, 15-16, and 17-18	STB-04	659020.40	3038399.44
5	The eighth refinery	Beach, phases 20-21	STB-05	656042.00	3042270.00
6	Pars, Pardis, Aryasaso, Zagros, Barzuyeh, and Jam	Beach	STB-06	652799.87	3047332.32
7	Mobin Petrochemistry	Beach Mobin	STB-07	651843.05	3048837.76
8	Kaviyan Petrochemistry	Beach Kaviyan	STB-08	650511.00	3050292.00
9	Damavand Petrochemistry	Beach Damavand	STB-09	650144.00	3050763.91
10	Morvarid Petrochemistry	Beach Morvarid	STB-10	649841.00	3050975.00

Table 2. How the stations are depleted and the level of depletion

No.	Refinery/petrochemistry	Local station	Depletion type	Depletion Débit
1	The first refinery: phase 1	STB-01	Channel or coastal pipes	6700
	The second refinery: phases 2 and 3			
2	The third refinery: phases 4 and 5	STB-02	Channel or coastal pipes	4500
3	The fourth refinery: phases 6, 7, and 8	STB-03	Channel or coastal pipes	1800-1950
4	The fifth refinery: phases 9 and 10	STB-04	Out-fall	13110
	The sixth refinery: phases 15 and 16			
	The seventh refinery: phases 17 and 18			
5	The eighth Petrochemistry: phases 20 to 21	STB-05	Out-fall	4500
6	Pars Petrochemistry	STB-06	Channel or coastal pipes	5500
	Pardis petrochemistry			
	Aryasaso Petrochemistry			
	Zagros Petrochemistry			
	Barzuyeh Petrochemistry			
	Jam Petrochemistry			
7	Mobin Petrochemistry	STB-07	Out-fall	6700
8	Kaviyan Petrochemistry	STB-08	Channel or coastal pipes	5500

9	Damavand Petrochemistry	STB-09	Channel or coastal pipes	15500
10	Morvarid Petrochemistry	STB-10	Channel or coastal pipes	4500

3. RESEARCH FINDINGS:

To this end, first, the numerical model of the wave is developed and the applied computational network, entering air, and the primary parameters of model simulation will be explicated. Then, sensitivity to the most effective factors on the results is analyzed and the effective parameters are selected to validate the results. Following this section, the results are validated using the measured data and the final calibration coefficients are extracted. All the stages mentioned above are carried out for the model of currents as well. After providing the final Setup for the models related to waves and currents and their respective results, the scenarios associated with the release of petrochemical wastes are presented. The numerical simulation results of releasing petrochemical wastes are presented for these scenarios.

Simulating the waves in the zone under the investigation

The current section is concerned with constructing and implementing the numerical wave model using MIKE21 software. The results are presented in the following.

Creating a computational network and depthometric file

Unlike other models such as SWAN, in MIKE21, the files related to computational networking and depthometric data are presented to the executive model altogether. Given the irregular and unstable situation of the coastal line, which is considered as the border area of the Persian Gulf somehow, triangular networking was used for the model in question. While selecting the dimensions of a triangulated network, the complexities and unexpected changes occurring in the borders should be taken into consideration. Given the fact that the coastal line of the Persian Gulf undergoes the highest levels of changes and details, the small dimensions of the triangulated network near the coastal lines are used. On the other hand, it should be taken into account that selecting small dimensions for the entire networking of the zone lengthens the computation period and often leads to convergence. Therefore, given the complexity and the drastic changes occurring in the zone under the study, a polygon is created to divide the different parts of the zone, and the size and dimensions of the triangulated network are determined according to the sensitivity level. Creating the networking file in the present study is conducted in a way that the most optimum size and number of networks in the computational field are applied. The network and depthometric files of the model are presented in figure 1 to analyze waves' creation and transfer. This networking has dimensions of 0.002 to 0.012 degrees at different points.

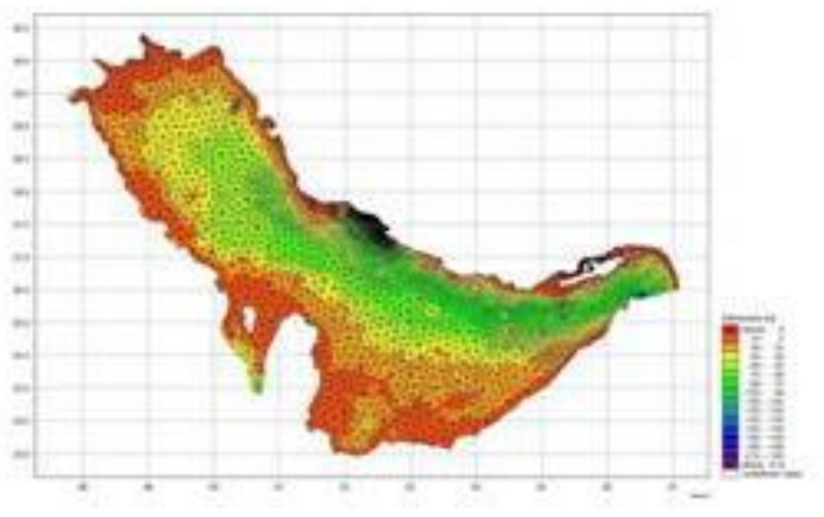

Figure 1. The utilized computational network for simulating the waves of the Persian Gulf

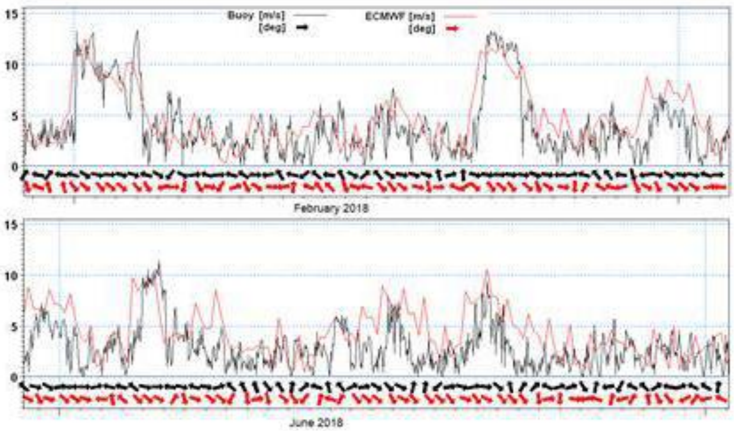

Figure 2. A comparison of time series charts about the speed and direction of the wind in Asaluyeh station during two months

Validating the level of entering airfield

The current study will utilize the ECMWF airfield for running the simulations. To validate the data related to the extracted air from the ECMWF aerology model, data on the point measurement of the winds blowing in Booyeh, Asaluyeh are used. Figure 2 compares the air data of ECMWF with data measured from Booyeh, Asaluyeh during two months in 2018.

Analyzing model sensitivity to different parameters

To validate and calibrate the numerical models, first, the factors to which the results are most sensitive are identified, and then the numerical model is calibrated using the identified factors. The sensitivity level of the results from the identified factors needs to be calculated. To this end, the other parameters are considered fixed, and then, by changing one particular parameter, any change in the results obtained is evaluated. In the stage of sensitivity analysis, some parameters or methods are either selected or removed from the modeling process according to their level of effectiveness.

Analyzing sensitivity to the size of computational networks

Different computational networks were created in different sizes to study the effect of computational network size on the simulation's accuracy and time. A model was run for each of them. Here, three computational networks are run with different spatial magnifications to present examples. Figure 3 presents an overview of the created networks in different sizes. Breaking down the computational network might, in some areas, increase the accuracy of the computations to some extent; however, this will be quite costly in terms of time. Therefore, if breaking down the computational networks does not make that much of a difference in the results, it is preferable to use less detailed networks as much as possible to reduce the time cost of the computations. Figure 4 compares the results of different computational networks in Booyeh, near the coast of Asaluyeh, respectively. The simulations were run on a computer with the following configurations: a 7-core CPU (Intel ® Core ™ i7-8550U CPU @ 1.80 GHz 1.99 GHz) and 12 GB of RAM. The time spent on each instance of networking was 50, 90, and 150 minutes, respectively. As it could be observed, in the beginning, further breaking down the computational networks has led to slight differences in the results. However, breaking down the computational networks even further has not made any significant differences in the results, aside from increasing the costs. Therefore, a network with the dimensions of 0.002 to 0.012 will be utilized to carry out the final computations.

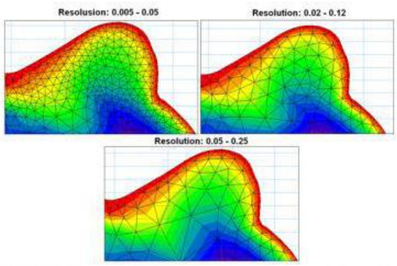

Figure 3. The constructed computational network in different sizes for carrying out sensitivity analysis

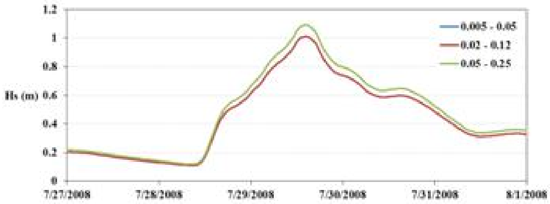

Figure 4. A comparison of the results obtained from models with different computational networks in Booyeh, near the coast of Asaluyeh

Sensitivity analysis to the number of angular divisions

The models were run for one particular storm with division numbers 16, 20, and 24. Results comparison related to wave heights resulting from the above models with different angular divisions in Booyeh, near the coast of Asaluyeh, presented in tables 4 and 5. As it could be observed, changing the number of angular divisions does not lead to a significant difference in the output of the models. Therefore, the same presumption, i.e., a division number of 16, will be used in the final models.

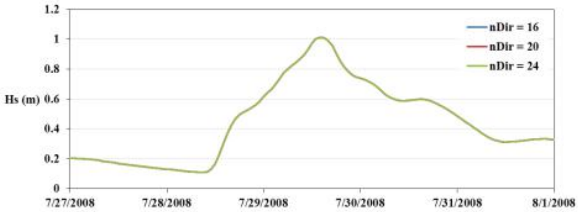

Figure 5. A comparison of the results obtained from models with different angular divisions in Booyeh, near the coast of Asaluyeh

Sensitivity analysis to the accuracy of the computational method

To this end, two models, one with low accuracy and one with high precision were run, and the results are compared in Booyeh, near the coast of Assaluyeh (figure 6). It is worth explaining that the model, by default, suggests utilizing the low-accuracy method. According to the following figure, the results suggest that the effect of the accuracy of computations on the model's output results is insignificant and can be made up for using other existing physical parameters in the relations. However, the high-accuracy method will still be used just for certainty.

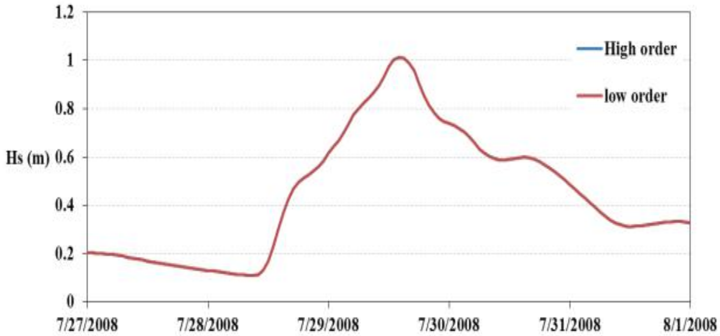

Figure 6. A comparison of the results obtained from models with different computational accuracy in Booyeh, near the coast of Asaluyeh

Sensitivity analysis to the coefficient of floor roughness

To test the level of sensitivity to this coefficient, the values of 0.04 (default value of the model), 0.01, and 0.005 were considered for this coefficient and the model was run on each of the afore-mentioned coefficients. The results related to the height of the simulated wave with differing Nikuradse roughness coefficients are compared in Booyeh, near the coast of Assaluyeh, with each other. As it could be observed, changing this coefficient in deep waters does not yield any kind of effect. However, it could be used as one of the convergence coefficients in shallow areas.

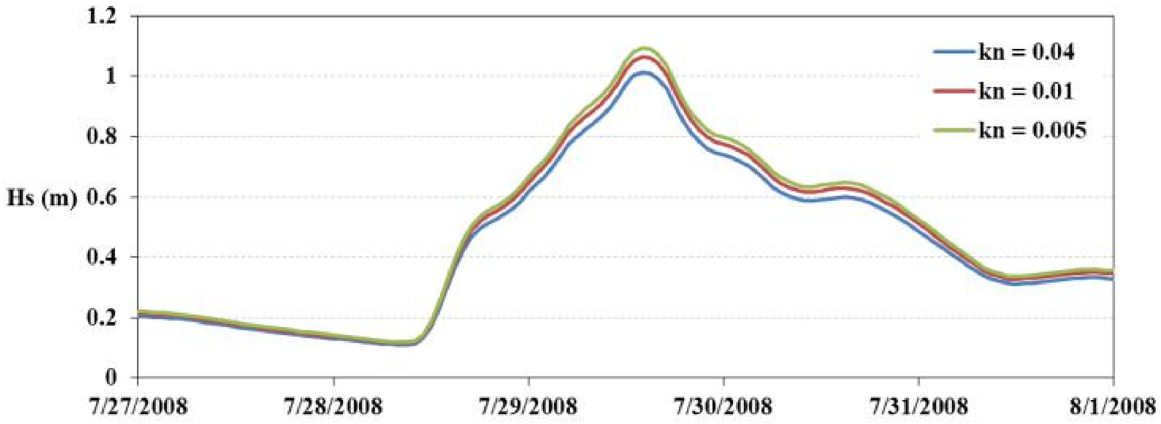

Figure 7. A comparison of the results obtained from models with different Nikuradse roughness coefficients in Booyeh, near the coast of Asaluyeh

Sensitivity analysis to the coefficient of wave refraction in shallow areas

In the current model, two coefficients have been considered: one for controlling the energy depreciation rate after wave refraction (parameter α), and one for controlling the depth level of wave refraction (parameter γ). An increase in parameter α would lead to an increase in energy depreciation rate and an increase in parameter γ would lead to a reduction in the depth of wave refraction. The calibration of the model with the parameters of wave refraction is only possible for shallow coastal areas (less than 4 meters of depth) in which wave refraction occurs. Therefore, a comprehensive model of such scale cannot be utilized as one of the parameters for calibration, and only the local small-scale models might be of more use. The results sensitivity analysis is presented, and these parameters have not affected the results. Thus, these parameters cannot be used for calibrating the models either.

Sensitivity analysis to the coefficient of wave white capping

Figure 8 compares the height of the extracted wave from the various ingredients of the parameter C_{dis}in Booyeh, near the coast of Asaluyeh. As could be observed in figure 8, the height of the simulated wave is significantly affected by the parameter C_{dis}; a reduction in this parameter would lead to a significant increase in wave height.

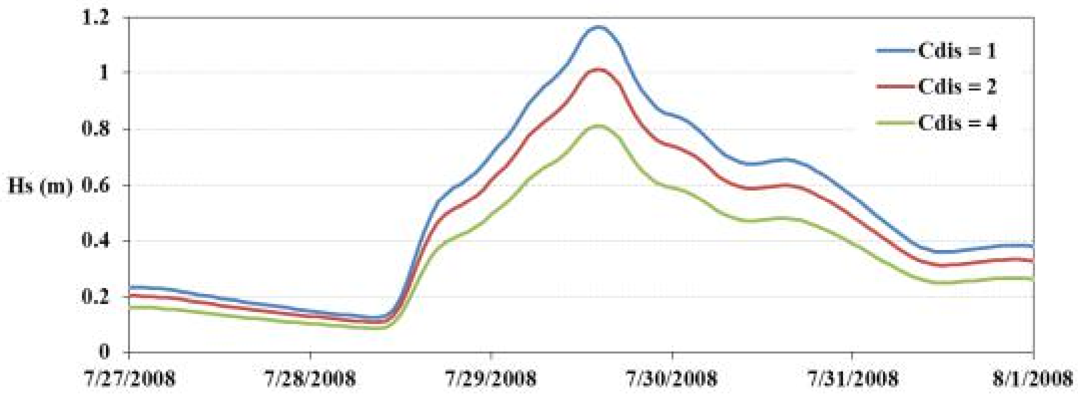

Figure 8. A comparison of the results obtained from models with different levels of wave white capping in Booyeh, near the coast of Asaluyeh

In order to further study the sensitivity of the parameters of wave white capping, in addition to the effect of wave height, the effect of the parameter $Delta_{dis}$ on wave period was also analyzed. Figure 9 presents the effect of changes in wave period ($T_{m,02}$) on the different forms of this parameter. As could be observed in figure 9, an increase in $Delta_{dis}$ directly affects the wave period.

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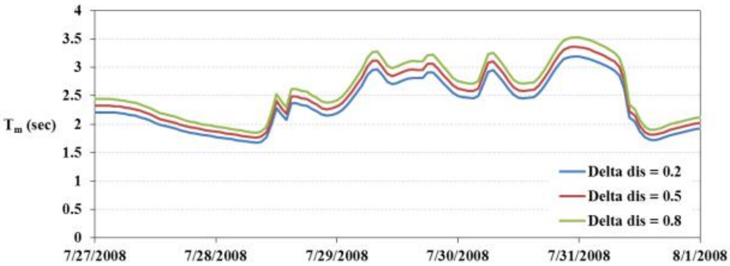

Figure 9. A comparison of the results related to wave periods obtained from models with different levels of wave white capping in Booyeh, near the coast of Asaluyeh

Calibrating model coefficients

Two longer than 1-month periods were selected in areas near Asaluyeh port for measuring waves to calibrate the model. The situation of this Booyeh is presented in figure 10. These periods were selected so that they could cover at least several storms. These periods include February and March of 2018. The coefficients of floor roughness and wave white capping calibrated the model. Figure 10 and figure 11 compare the measured wave height with the simulated values (in both the calibrated and non-calibrated forms) in Booyeh, Bushehr, and Asaluyeh for March 2018. As observed, both in Bushehr and in the area near Asaluyeh port, the values of wave height taken from the model improved significantly after calibration, and they were approximated qualitatively to many of the measured values. Figure 12 and figure 13 are related to the period of March 2018.

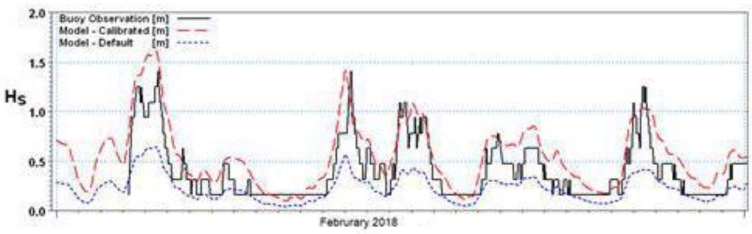

Figure 10. A comparison of measured wave heights with the simulated values (in both the calibrated and non-calibrated forms) in Booyeh, Bushehr in February 2018

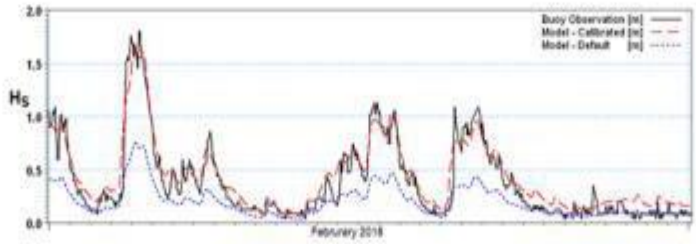

Figure 11. A comparison of measured wave heights with the simulated values (in both the calibrated and non-calibrated forms) in Booyeh, Asaluyeh in February 2018

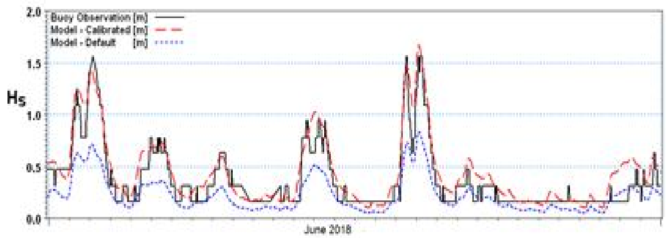

Figure 12. A comparison of measured wave heights with the simulated values (in both the calibrated and non-calibrated forms) in Booyeh, Bushehr in June 2018

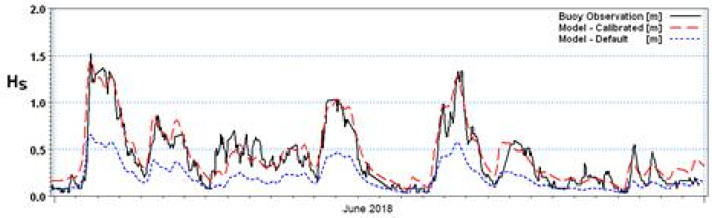

Figure 13. A comparison of measured wave heights with the simulated values (in both the calibrated and non-calibrated forms) in Booyeh, Asaluyeh in June 2018

Error indices were used for measuring the simulated values resulting from calibrating the model quantitatively compared to the measured values. It should be noted that, according to the previous studies and the existing recommendations, the calibration operation of the model is conducted based on minimizing the wave height. A comparison was made between the calibrated model results and the measured data in Booyeh Asaluyeh, and the results are presented in figures 14 and 15 (These data were not available for Booyeh, Bushehr) to evaluate the predicted values for the wave period. According to the figures, the modeled period values agree with the measured values.

Figure 14. A comparison of measured wave peak period (Tp) with the simulated values in Booyeh, Asaluyeh during February 2018

Figure 15. A comparison of measured wave peak period (Tp) with the simulated values in Booyeh, Asaluyeh during June 2018

The simulation of sea currents in the zone under the study

The changes in water level and currents in the Persian Gulf are, for the most part, the result of ebb and flow. In general, the water enters the Persian Gulf along the northern coasts and exits along the southern coasts. The width of currents moving against the stream varies in different seasons. In summer, the entering water current is wider than other seasons, and a significant reduction in the width occurs in winter. In general, the ebb and flow streams ebb towards the west and northwestern and flow in the opposite direction.

The current section is concerned with constructing and implementing a numerical model of ebb and flow. The current resulting from wind using MIKE21-SW software and the results are presented. Furthermore, the results of sensitivities are independent of the model used and their results are given for the two models separately. Therefore, the numerical model for the wave is constructed first, and then the utilized computational network, border situation, and the primary parameters for model simulation are explicated. Furthermore, the results related to the sensitivity analysis to the most influential factors on the wave model results are presented. Moreover, measurable data are used for validating the results of the model.

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Computational network and depthrometic file

Creating the networking file is conducted so that the most optimum number and size of networks are made use of in the computational field. To this end, a sensitivity analysis is conducted to measure the dependence ratio of the results of the water current model on the size of the computational network; the results are presented in the following sections. The networking and depthometric files for analyzing the current and water level are presented in figure 1. This networking includes 0.002 to 0.012 degrees at different points. In the implemented currents model, based on the features of numerical solutions of the equations, the value of the time step is considered between 0.01 to 60 seconds. The utilized numerical model has the potential to use the largest possible time step according to the conditions of numerical stability. The information on changes in water level in Sirik port, which was extracted from the maps drawn by the National Cartographic Center of Iran, was used in the entry border. Figure 16 suggests the changes in water level in this station. Throughout the modeling process, the effects of the dryness resulting from ebb and flow on the coasts are taken into consideration. Also, as pointed out in the section on waves simulation, the information on wind output of the ECMWF airfield model was used. The results of sensitivity analyses conducted on the outputs of the currents model to the effective factors on modeling are presented in the following.

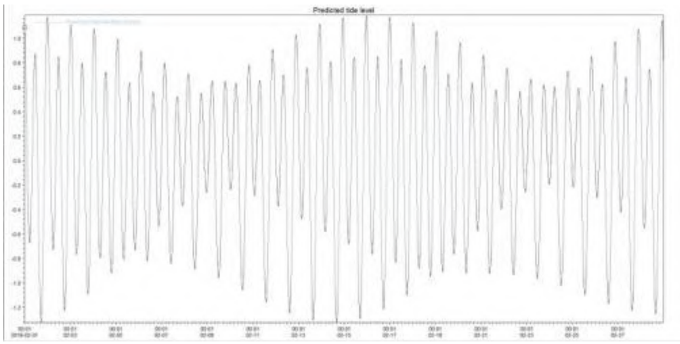

Figure 16. Changes in water level in the stations of Sirik port for one month

Analysis of model sensitivity to different parameters

In the current section, the sensitivity of the results obtained from the currents model to the size of the computational network, the numerical accuracy of the computations, the coefficient of floor roughness, the effect of Coriolis force, the coefficient of wind roughness, and the coefficient of eddy viscosity are studied.

Analysis of model sensitivity to the coefficient of floor roughness

One of the determining factors in the speed of water current, especially in shallow areas, is floor roughness. Figure 17 compares the water level results in different models with different floor roughness coefficients in Booyeh, away from the coast of Bushehr. Also, the results about the changes in the current speed at this very point are presented in figure 18. The comparison of the results related to water level and current speed in models with different levels of floor roughness in Booyeh, near the coast of Assaluyeh, are presented in figures 19 and 20. As observed in the following figures, floor roughness affects all the results. An increase in the manning coefficient (a reduction in the coefficient of floor roughness) would lead to an increase in current speed and water level. It could be explained by reducing floor tension and resistance against streaming due to a reduction in floor roughness. Given the high susceptibility of water level and current speed to floor roughness, this parameter will calibrate the model.

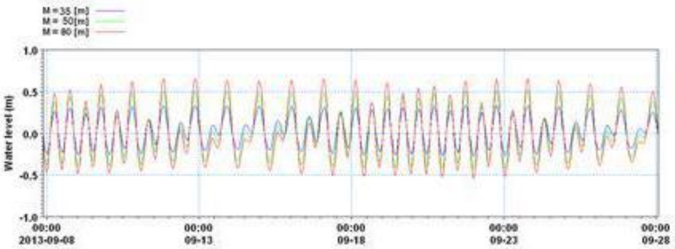

Figure 17. A comparison of the results of the level of exiting water in models with different coefficients of floor roughness in Booyeh, away from the coast of Bushehr

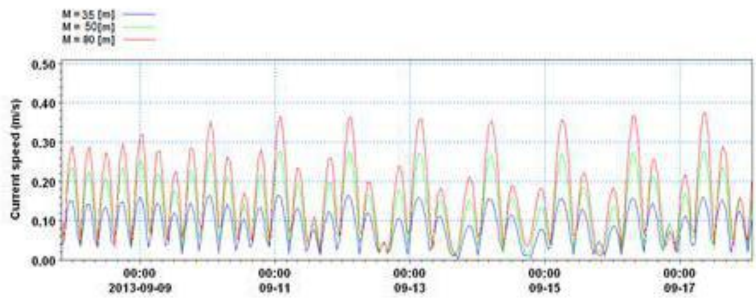

Figure 18. A comparison of the results of current speed in models with different coefficients of floor roughness in Booyeh, away from the coast of Bushehr

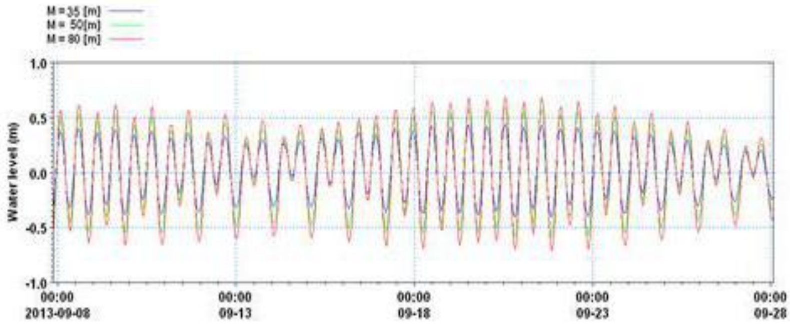

Figure 19. A comparison of the results of the level of exiting water in models with different coefficients of floor roughness in Booyeh, near the coast of Bushehr

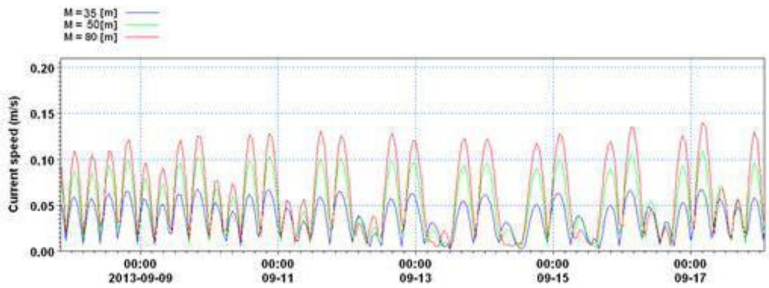

Figure 20. A comparison of the results of current speed in models with different coefficients of floor roughness in Booyeh, near the coast of Asaluyeh

Analysis of model sensitivity to the effect of the coefficient of wind roughness

In areas that are not covered by ice, surface tensions $(\tau_s = (\tau_{sx}, \tau_{sy})$ are measured via the wind blowing at the surface. By changing the value of wind roughness coefficients, the shear stress imposed on the surface due to wind blowing changes and, thus, stream speeds change. This can be the case, especially in situations when the wind is blowing strongly and can, thus, change the stream speed. In addition to water stream, water levels can be affected strongly by the wind's speed and direction. Therefore, the wind roughness coefficient should be selected with great care and accuracy.

The implementation and the results of the model of petrochemical waste release

The current section is concerned with how petrochemical wastes are released as a result of sewage leakage in the areas near the northern coasts of the Persian Gulf. The situation of sewage disposal stations is presented in figure 21. Here, the results obtained from different scenarios related to the release of petrochemical wastes are presented, and the most critical scenarios are identified, so a solution is proposed to minimize the release and distribution of petrochemical wastes.

Figure 21. The situation of stations for disposing of petrochemical wastes

Two kinds of information are required to implement the numerical model for the release of petrochemical wastes: general information (including hydrodynamic information, e.g., wind, wave, current, water level, etc.) in the area under study; and, also, the characteristics of petrochemical waste pollution. The method for the numerical modeling of the waves and current field in the computational area were already discussed in-depth, and the respective results were also presented.

Defining the scenarios on the spread of pollution based on the contributing factors to the spread of pollution

Defining different scenarios on the spread of oil pollution is done according to the different environmental factors contributing to oil spread. One of the most important factors contributing to this matter is the water temperature in a polluted area. In summer, water temperature is 33 degrees centigrade and, in winter, it drops to 18 degrees centigrade.

Studying the results of model output

Given the output models from February to June, which were representative of cold and hot seasons, respectively, and also according to the analysis of current vectors, it is observed that the released petrochemical wastes from the stations, after a minor spread in the sea (60 meters towards the sea) moves towards the coast through surface currents and engaged with the waves and currents in the proximity of the coast and is spread along the coastal line. Figure 22 depicts the planimetric situation of the stations, and figure 23 presents a one-minute time step in February in which the spread of petrochemical wastes from the main source to the coast is visible. Furthermore, as we get closer to the ebb hours of the sea, the scope of pollutions resulting from the release of petrochemical wastes increase, and this increase can be accounted for by water intrusion. Obviously, at flow time, this pollution is left on the sand. Consequently, cases of pollution left in coastal areas as a result of ebb and flow need to be taken into account. A comparison of summer and winter suggests that when petrochemical wastes are released in waters whose temperature is between 18 to 33 degrees centigrade, the release scope is not so much dependent upon the temperature of the surroundings. Also, changes in solar radiation are only effective in the vaporization of light components, which occurs in the first few hours anyway. Studies suggest that the most important factor contributing to the spread of petrochemical wastes pollution is the condition of ebb and flow. Critical ebb and flow conditions can also occur during winter or summer. A comparison between the results of summer and winter suggests that there is no significant difference between these two seasons in terms of the scope of the spread of petrochemical waste pollution in the sea.

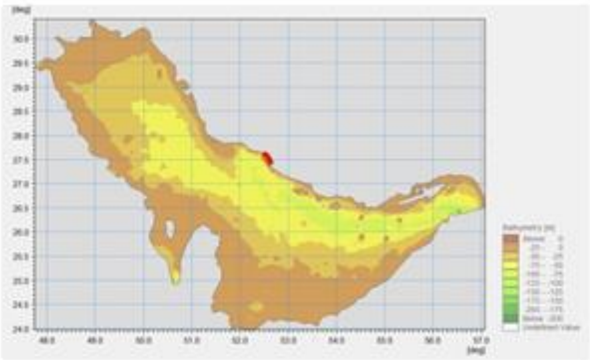

Figure 22. The situation of stations for disposing of petrochemical wastes

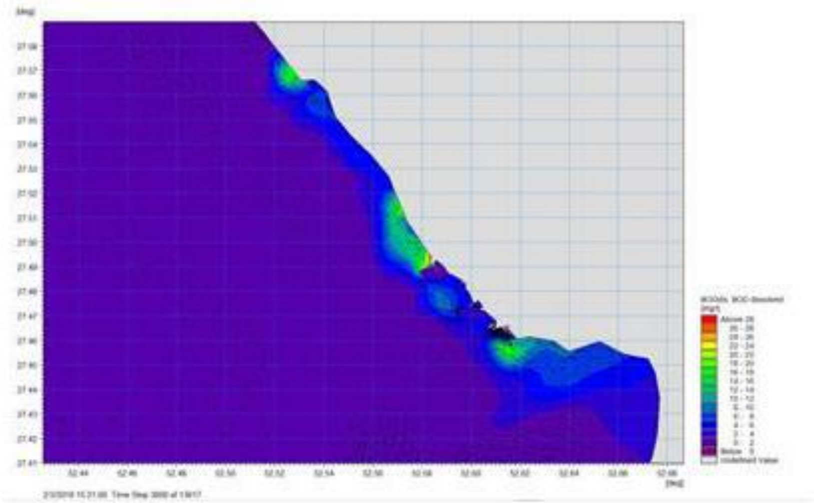

Figure 23. How petrochemical wastes are spread and transferred from disposal stations to the coasts of Asaluyeh and Nakhl Taghi

4. DISCUSSION ANS CONCLUSION:

Petrochemical wastes comprise chemical pollutants that their release and spread can have irreparable complications for the environment and sea ecosystems. In general, petrochemical waste release occurs when refineries consider disposing of the wastes in seawater. Given that the release of petrochemical wastes might be done in different environmental conditions, different measures must be taken to control them. To this end, the model of petrochemical wastes needs to be determined; hence the numerical modeling of petrochemical wastes release and the effective factors on the matter was studied in the present research. Numerical modeling tools were utilized for this purpose. First, waves and currents, as the most important factors on the distribution and transfer of petrochemical wastes, were numerically simulated using MIKE numerical model. Then, the release and spread of petrochemical wastes in the Persian Gulf region and Assaluyeh port has been conducted by taking into consideration all the effective factors, including wind, ebb and flow, waves, temperature, etc. Eventually, several solutions were presented in accordance with the model of waste spread. A comparison of the results of summer and winter suggests that water temperature is between 18 to 33 in these seasons and that the spread of petrochemical wastes is not much dependent upon the surrounding environment. Furthermore, changes in solar radiation are only effective on the vaporization of light components; however, this only occurs in the first few hours. It was suggested that the most important factor in the transfer and spread of petrochemical wastes is the condition of sea currents and ebb and flow. Critical ebb and flow can occur in both summer and winter. A comparison of the results of summer and winter suggests that there is no significant difference between the spread scope of petrochemical wastes in seas between the two seasons.

5. RECOMMENDATIONS:

1. Identifying and modeling ship movements in the area of petrochemical waste stations and the effect of their movement model on surface currents
2. Accurate identification of wastes and quantitative and qualitative measurement of pollutants in all petrochemical units which dispose and release wastes in the sea.
3. Construction of well-rounded and up-to-date sewage-treatment plants
4. The development of green space and irrigating them using treated industrial sewage
5. Proper clarification and propagation about the activities of the petrochemical industry (unfortunately, in some cases, are not clear in the information they present to the public so they could escape the complications of having to deal with the Environment Protection Agency.

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