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The effect of marine parameters on salinity via statistical approaches

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Abstract. The purpose of this study was to identify the relationships between water quality parameters of marine water and to determine parameters that affect much on salinity of surface water. This is a quantitative study which focusses on modelling of salinity on three marine parameters (temperature, dissolved oxygen and conductivity) from six monitoring stations in the Straits of Johor, Malaysia. Pearson correlation indicates the occurrence of significant linear relationship between salinity and conductivity for each station. The regression model of salinity shows some significant effects of a few marine parameters. A significant correlation of about 0.8 between salinity and conductivity for all stations shows that their relationship is moderately high as compared to temperature and dissolved oxygen. The fitted models indicate that similar ecological conditions can be observed at one of the monitoring stations for each Western and Eastern parts of the Straits of Johor as the salinity is dominantly influenced by the changes in temperature, dissolved oxygen and conductivity.

1. Introduction

Ocean is the biggest water source notwithstanding being the principle medium for the different sorts of transport and living species. Contamination brought about by modern, rural and metropolitan squanders, seaward and seaside generation of oil and gas, shipping organizations and different conditions has lead into debasement of its biodiversity, fumes of fish assets and expanded changes of the ocean level [1]. Development of the thoroughfare influence water quality in the Straits of Johor on the grounds that the stream of ocean water consistently frustrated by the structure. The causeway has brought about blockage in the typical stream of the Strait and prompt the spread of standing waves without stream at the boulevard has exacerbated the circumstance [2]. Expulsion of oil conveyed by the ship is one of the elements that lessening the level of water quality in the Straits of Johor. Moreover, the release of waste from the plant to the Straits of Johor exasperates the water quality in the range. Current way of life has prompted expanded utilization of pharmaceutical items is one case of contamination in the region [3].

Water quality parameters including temperature, salinity, dissolved oxygen and turbidity levels were distinguished influence the dispersion of fish [4].

Salinity is one of the critical natural components influencing survival, development and conveyance of numerous sea-going life forms [5]. Changes in salinity level will influence marine life. Hence, a study to recognize changes in the salinity of the ocean water is critical in deciding the level of marine water quality. Angle presented to expanded salinity are probably going to confront a contention between the instruments of salt take-up and supplement take-up in the gut [6]. Broken down oxygen is essential for the survival of marine life [7] and the diminishment of sustenance exercises and developments by the life form, the rate of oxygen required by living beings will be decreased [8]. Marine water require oxygen least is 4 mg/L and ideally with 5 mg/L for the arrangement of biological system working with ideal levels to marine life [9]. Wellspring of oxygen in inundated regions is through the procedure of photosynthesis by marine plants [10].

Johor Straits is a standout amongst the most vital zones of Peninsular Malaysia as a region of mangroves, corals, kelp and biological community of mudflats [11]. Different advancements are progressing in the region of the Straits of Johor water system give a negative effect to the Straits. One speculation was made by [12] expressed that the nature of water in regions with modern exercises will contrast from those of regular environments, for example, ocean grass and mangroves. In this quickly developing world, it is imperative to moderate such profitable littoral assets, for example, shorelines, coral reefs, mangrove woodlands, and seaside tidal ponds and furthermore preserved fisheries, natural life and water quality [13]. The objective of this study is firstly, to explore the relationship of salinity and each of the marine parameters. Secondly, to determine the effect of marine parameters on the surface water salinity.

2. Materials and Methods

2.1 Study area and Monitoring Sites

The study was in the Johor Strait, generally called the Tebrau Straits arranged in southern Peninsular Malaysia with a length of about 53 kilometers. Straits of Johor extremely restricted and shallow with a locale of around 4 kilometer strait that partners the Strait of Singapore [14]. Johor Strait is an overall strait that segments the projection of Malaysia and Singapore which situated at the southern tip of Peninsular Malaysia, which lies between two terrain solid territorial Johor and Singapore, is the just a single the busiest transportation paths and has a key topographical position of both the east and west [15]. There are 38 stations that work to give data of various water quality parameters in the Straits of Johor. An aggregate of 6 stations decided for this survey, to be particular stations B1, B2, B3 and in the east of the Straits of Johor and A1, A2 and A3 in the west of the Straits of Johor.

The reason Straits of Johor were picked in light of the way that the site arranged at strife between the 2, to be particular Malacca Strait and the South China Sea, which occurred under semi-limited water body condition. From that, the survey will see the typical wonders amidst the shoreline strategy for East and West. The key site territory which are fundamental in this audit in light of the way that if the survey driven in any zone of marine water, which does not have a contention between the 2 straits, the delayed consequences of water quality developing on account of these customary marvels won't be gotten and recognized. Straits of Johor is one and the primary course between two domains and besides in a key land position in the busiest conveyance ways in the both toward the east and west [16].

Johor Strait to Malaysia to supply ordinary resources and open entryways for both countries, Malaysia and Singapore for conveyance. The offer favored outlook to this audit since it will give a strong inspiration to investigate the impact of conveyance activities and waste water discharge and it will perceive whether both of whirlwind water and waste water discharge from the both countries can

negatively impact water quality thusly will affect salinity. As showed up in Fig. 1, station B2 and B3 are arranged close estuary where the mixing between new water and saline water will happen. B1 are arranged at the eastern end of Straits of Johor while the other three (A1, A2, A3) which arranged at the west bit of Johor Strait are arranged far from the estuary. The zone of station accepted essential part in this survey.

Figure 1: Location of study area and monitoring stations.

2.2 Data Preparation

Data used for this study were acquired straightforwardly from the National University of Malaysia (UKM). Information from 2003 to 2014 for the six checking stations chose the B1, B2 and B3 on eastern piece and A1, A2 and A3 are on the west side of the Straits of Johor. Data can be acquired from the perception information for an assortment of parameters for each station. The data incorporates information for different water quality parameters on a month to month premise and the profundity of the water surface, centre and base of the ocean. In this study, the data that required salinity, temperature, dissolved oxygen and conductivity of the surface water in the Straits of Johor.

2.3 Multiple Regression Analysis

The use of multiple regression analysis in this study will produce a model that will be used to determine the trend rate of salinity in the Straits of Johor from 2003 to 2014. The multiple regression modelling method to produce a model that has more than one response variable [17]; [18].

$$Y = B_0 + B_1x_1 + B_2x_2 + \cdots + B_kx_k + \in (1) \qquad (1)$$

Referring to equation (1), B_0 an intercept on the y axis and B_1, B_2, ..., B_k as the coefficient for the slope of which is also called partial regression coefficients.

3. Results and Discussion

Selected parameters for this model are the parameters that have been identified to result in a significant relationship to salinity levels with a p-value less than 0.05 ($P < 0.05$).

Station	B1		B2		B3		A1		A2		A3	
	r	P - value	r	P - value	r	P - value	r	P - value	r	P - value	r	P - value
Temperature (^{0}C)	-0.029	0.744	0.023	0.793	0.134	0.126	-0.179	0.041	-0.009	0.918	-0.114	0.195
Dissolved Oxygen (mg/L)	-0.189	0.03	-0.313	0	-0.25	0.004	-0.038	0.665	-0.136	0.12	-0.182	0.038

Conductivity (μS/cm)	0.788	0	0.768	0	0.812	0	0.752	0	0.829	0	0.822	0

Table 1: Results from Pearson's correlation

Based on Table 1, there is only one station indicating that the temperature is one parameter that affects the rate of salinity which is A1. *r*-value for salinity levels against temperature at the station A1 is - 0.179 and the significance is 0.041 (<0.05). As for the relationship between salinity and dissolved oxygen levels there are only four of the six stations were selected that showed evidence that the parameters affecting the rate of salinity and dissolved oxygen. Four stations are stations B1, B2, B3 and A3 for having the p smaller than 0.05 for the value of r is generated. B1 station has the highest r values - with significant value 0.000 0.313. As for the relationship between salinity and conductivity, all values of r resulting from the analysis of Pearson correlation was significant for all stations. Rated R for A2 station is the highest for this relationship when compared with the value of r at the station - another station. Rated R for A2 station for the relationship between salinity and conductivity is 0.829 with significant value 0.000.

Station	**Temperature**		**Dissolved Oxygen**		**Conductivity**	
	B_1	**P-value**	B_2	**P-value**	B_3	**P-value**
B1	- .253	.018	- .260	.038	48.372	.000
B2	- .048	.696	- .447	.116	41.796	.000
B3	- .057	.154	- .439	.126	42.004	.000
A1	- .213	.038	- .084	.489	41.443	.000
A2	- .153	.082	- .367	.002	49.751	.000
A3	- .384	.000	- .457	.001	50.480	.000

Table 2: Multiple linear regression

According to Table 2, station B2 and B3 has only one parameter involved for the production model salinity levels at each station, which conductivity. The p-value for the conductivity of the both stations is 0.000. The p value less than 0.05 causes the parameters to be taken into account in the production model for the salinity levels at each station. The p-value for temperature and dissolved oxygen parameters for both stations are more than 0.05 (P> 0.05). This means that the conductivity parameters can only be used in the model for the salinity levels of the both stations. Study by [19] also indicates a significant relationship between salinity and conductivity. For temperature, A3 have the lowest p-value that is equal to 0.000 (P = 0.000) where it says the most significant in compared with two other stations (B1 and A1) and p-value for the temperature parameter at each station are 0.018 and 0.038. For the model that contains dissolved oxygen, A3 station also said the most significant with a p-value is 0.001 and is the smallest compared to the value p for a model for salinity that contains oxygen in other stations.

Station	**Model**
B1	$\hat{S} = -187.369 - 0.253\ T - 0.260\ DO + 48.372\ C$
	(15.256) (0.105) (0.124) (3.246)
B2	$\hat{S} = -161.463 + 41.796\ C$
	(14.719) (3.072)
B3	$\hat{S} = -166.758 + 42.004\ C$
	(13.116) (2.754)
A1	$\hat{S} = -157.225 - 0.213\ T + 41.443\ C$
	(15.615) (0.101) (3.218)
A2	$\hat{S} = -196.345 - 0.367\ DO + 49.751\ C$
	(13.225) (0.114) (2.813)

A3	$\hat{S} = -192.675 - 0.384\,T - 0.453\,DO + 50.480\,C$	
	(13.851) (0.104) (0.128) (2.887)	

Table 3: Model of salinity level each station

$$S = B_0 + B_1\,T + B_2\,DO + B_3\,C + error$$

where

S = Salinity (ppt)
T = Temperature (°C)
DO = Dissolved Oxygen (mg/L)
C = Conductivity (µS/cm)

According to Table 3, difference in the resulting model for each station involved can be clearly seen. To produce the model for the study of water salinity, water salinity levels were used as manipulating variable (dependent) while the parameters of water quality that affect the change in salinity levels of water as the responding variable (independent). B1 and A3 involving all significant parameters with the salinity levels of salinity in the model generated for the both stations. For station B2 and B3, the resulting model involves only parameter of conductivity. This is because the p-value for other water quality parameters exceeding 0.05 for the station. A1 Station involving temperature and conductivity parameters in the model generated by this analysis. The bracket under each coefficient represents standard error of the model. The error can be reduced by considering other significant parameters into the model.

Through different relapse examination, just the parameters of water quality that were fundamentally connected with salinity levels for each station will be considered in the generation show for each station. An aggregate of 6 models for salinity levels in light of time created in this study. The subsequent model includes parameters of water quality, for example, temperature, dissolved oxygen and conductivity. Model of salinity levels in station B1 and A3 included parameters of temperature, dissolved oxygen and conductivity. For station B2 and B3, demonstrate for the salinity of ocean water salinity level included parameter conductivity as it were. In view of the model outcome for both stations, salinity levels will increment with expanding the conductivity. Station A1 show including temperature and conductivity parameter for the model of salinity levels of the station. The subsequent model of different relapse examination for A2 station just included parameters of conductivity and dissolved oxygen to create a model for the salinity levels of the station.

The level of salinity in the surface water can influence other marine water quality parameters, for example, temperature, dissolved oxygen and conductivity. Impact for parameter of water quality that influences the salinity is distinctive relying upon the conditions encompassing each station. Expanded salinity levels in accordance with the expansion in temperature as indicated by a study directed by [20]. The temperature of ocean water is between 28°C to 32°C [21]. Ocean water salinity levels will be continually changing relying upon the topographical circumstance of a place and always shows signs of change after some time. In the tropics, changes in salinity levels are extremely perceptible where the atmosphere is described by dry and stormy season [22]. What's more, the presentation of new marine types of the region can be relied upon because of the decline in salinity, and a synchronous increment in water temperature [23].

Although Table 2 shows only one station indicating that temperature is significant in determining salinity level, technically, temperature does affect the salinity level if not major, a minor contributor. By considering other factors such as conductivity and dissolved oxygen, there is a minor contribution of temperature parameters when determining salinity level. Study by [24] shows that the correlation between temperature and salinity is not the same along North Atlantic, and there is a part where it has low correlation due to lack of salty water from the Labrador Sea. Hence, it is important to consider

temperature parameter when determining the salinity level. The principle abiotic components that direct untamed life, the primary procedure in natural chemistry and physiology of fish is the temperature [25]. Sudden temperature changes will make the relocation of a few types of fish different territories [26]. Physical procedures (water streams, anthropogenic obstruction) and exercises of benthic life forms (tunnelling, water system) can bring about the event of silt and dregs blending with oxygenated water is continually rehashed [27]. The quantity of high precipitation rule the hydrological cycle tropics [28]; [29] and prompt the arrangement of water with salinity bring down in surface water [30]; [31] that influences the flow and thermodynamics in tropical seas [32]; [31]. New water is a mass flux and when added to the surface of the ocean (with rain), it presents changes sea at different worldly and spatial scales [33] created the aggregate amount of salt in the water will be continually changing because of the arrival of water from the stream adjacent [34].

Sea ebb and flow that courses through the Straits of Johor gotten from the South China Sea. Ocean situated between Peninsular Malaysia and Borneo is the southern piece of the South China Sea. As a rule, the ocean is a continuous storm. The regular rainstorm winds turn around assume an essential part in the hydrological attributes and the general course of the South China Sea [35]; [36]. A study was led by [37] on the surface of the water temperature and the impact of the development of the ebb and flow stream of worldwide sea display all through Peninsular Malaysia demonstrates the appropriation of water is firmly affected by the ebb and flow streaming toward the south amid the upper east rainstorm.

Upper east rainstorm hit the southern piece of the South China Sea occurred in November and March bring solid winds upper east and the southwest storm that hit the area happened from April to August, bringing a solid northwest wind [37]. [38] in their study demonstrated that the temperature and salinity recorded amid the upper east rainstorm is low. A study directed by [39] that gather and break down information on salinity, temperature, disintegrated oxygen and water masses Vietnamese waters demonstrate that low salinity water close to the mouth of the stream.

Conclusion

The study of salinity, temperature, dissolved oxygen and conductivity in the Straits of Johor has achieved its purposes. Marine parameters were analysed by using DOE standard and the relationships between salinity and each of the remaining three parameters are observed. It is due to the natural features of the three marine parameters in influencing the variation of salinity. The salinity at six monitoring stations namely stations B1, B2 and B3 in the east of the Straits of Johor and A1, A2, and A3 in the west of the Straits of Johor could be distinguished by different marine parameters. The salinity at stations B2 and B3 are only influenced by conductivity in which their locations are closer. Station B1 which is located in the southern part and moderately far from B2 and B3 shows different feature of salinity as it is greatly influenced by temperature, dissolved oxygen and conductivity. The salinity at stations A3 is dominantly influenced by the three marine parameters. Dissolved oxygen and temperature do not contribute to the changes of salinity at stations A1 and A2, respectively.

The hydrodynamic currents along Singapore Strait are controlled by semi-diurnal tides with bias in both directions, namely eastern (Southwest monsoon) or western (Northeast monsoon). The salinity distribution within the coastal waterways had effects towards the relative influx of fresh water which supplied by the rivers, and depends on mixing ability of receiving water [40]. Temperature, dissolved oxygen and conductivity had known to have significant impact on the salinity in the south east and south west parts of Singapore.

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