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GIS-based water quality index of marine water along residential, commercial and recreational areas in Opol, Misamis oriental, Philippines

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Abstract

This study dealt with the application of Geographic Information System (GIS) vis a vis water quality index of marine water ecosystem in Opol, Misamis Oriental. Specifically this study aimed on (a) establishing GIS maps on wide range distribution of physicochemical parameters of water (b) determining the physicochemical parameters of water along residential, commercial and recreational areas and (c) comparing the values of physicochemical to the standards set by Department of Environment and Natural Resources (DENR) Philippines. There were three (3) sampling stations categorized as residential, commercial and recreational areas and sampling was conducted within three (3) months during *Amihan* (northeast monsoon) in the Philippines. Research design used was a combination of descriptive, qualitative and evaluative design. Results showed Relative Humidity (RH), air temperature, Dissolved Oxygen (DO), water temperature, density, conductivity, turbidity, salinity, and Total Suspended solids (TDS) were prevalent in recreational area, while DO and Biochemical Oxygen Demand (BOD) in commercial area, and only pH and BODin residential area. Statistical analysis showedsix (6) andeight (8) of the parameters in between subjects and within-subjectsshowed significant difference, respectively. However, one-sample t-test showed that the three sites are equal and not statistically significant. Hence, GIS is an effective tool to assess area for possible distribution of species and vulnerability to polluted waters.

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Introduction

Water can be ascribe with various of colors due to the wastewater that originates from places like house-holds, commercial, developments, industries, runoff and so on. This, in turn, may lead to pollution problems such as contaminated drinking water, eutrophication, suspended solids and solid wastes Ahuja (2014). Impacts on fish production and on the ecosystem has also been observed due to anthropogenic and climate changes. Climate change drive mostly on marine species, most rapid changes occur on fish communities, which in turn, affects the physical, chemical and biological processes of marine species and its ecosystem (Barange and Perry, 2009). An increase in population involves an increase of necessities in terms of food, economy and other related matter. Thus, to boost the community's economy, one should allow investments from local and international stakeholders. One of widely known investments include restaurants along the coastal area and recreational business such as beach hotels and resorts.

As the growth of population increases, marine along the coastal regions, developmental activities and human settlement have greatly added environmental impact on downstream estuarine, as well as coastal ecosystems (Shirodkar *et al.* 2008). One prominent problem that takes place is the depletion of oxygen, due to biological growth of certain algal species, and eutrophication which caused by nutrient enrichment in many parts of the world (e.g. Turner *et al.*, 1999; NRC, 2000; Bodungen and Turner, 2001). These are some characteristics of human-related perturbations which can be closely related to land uses. These reasons encouraged the researchers to conduct the study in Opol, Misamis Oriental.

Opol, Misamis Oriental is a coastal area which is considered as one of the fastest growing municipalities as identified by LGU 2015. It is being surrounded by a public market, business establishments and residential areas. Human activity is considered one of many things that may cause destruction in most aquatic ecosystems.

Such activities involve are improper waste disposal, debris coming from construction sites, and excessive recreational activities. Apart from this, the growing population considers a big part in increasing humans' needs, which may in turn, cause a great impact to the changes in aquatic ecosystem. Up to date, Opol, Misamis Oriental has not yet given the present status since 2010 and it has become a major concern that marine water is subjected to the effects of climate change. Some of its known effects are the frequency and intensity of storms, prolonged heat waves, changes in precipitation patterns and sea-level rise (Ahuja, 2014). Not only shifts in means of the increasing and decreasing of evaporation, precipitation and temperature variation, but more likely to experience more severe and frequent events such as storms (Francis and Hengeveld, 1998).

Furthermore, the application of Geographic Information System (GIS) on water quality of the marine water requires not only on the investigation of water pollution but also to visualize the spatial pollution characteristics and identifying potential polluted areas. This is manifested in the different models or digitized maps generated in the study (Fig. 3 and 4).

Hence, the study answers to the following objectives to: (i) establish GIS maps on wide range distribution of physicochemical parameters of water, (ii) determine the physicochemical parameters of water along residential, commercial and recreational areas, (iii) compare the values of physicochemical to the standards set by DENR Administrative Order no. 34 (DAO 34) in the Philippines and (iv) draw-out intervention for a sustainable and environment-friendly marine water ecosystem.

Materials and Methods

Research Design

Research design used was a combination of descriptive, qualitative and evaluative design. The descriptive component explained the results obtained from physicochemical analysis of marine water while qualitative part entails the discussion of GIS and its implication. The evaluative component design explains the values of physicochemical to the standard set by DENR, Philippines.

Sampling site

The study was located at the municipality of Opol, Misamis Oriental in Northern Mindanao. It has ageographic coordinates of 8°31' 0'' N, 124°34' 0'' E. According to the census of Philippine Statistics Authority in May 2010, the population of Opol has reached 52,108. With the vast changes in the area, most of their barangays were used to many developments such as resorts, hotels and restaurants, industrial companies and more.

Fig. 1 below shows the map of Opol, Misamis Oriental wherein three (3) sampling stations were established. Sampling site1 is located in Barangay Luyong Bonbon, near a company distributor, categorized as residential area. The second site is located in Barangay Poblacion, where establishments such as restaurants, public market and more are located which makes the area as commercial. And sampling station 3 is located in Barangay Taboc, which is situated along several beach resorts or recreational area.

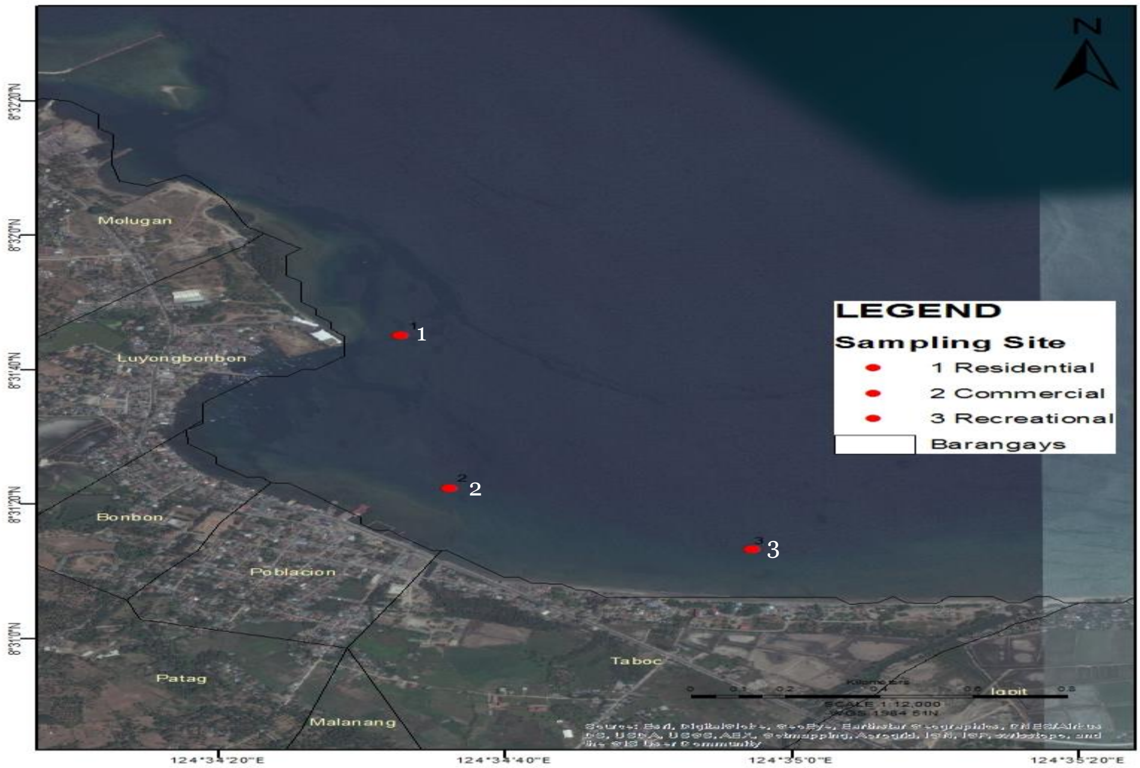

Fig. 1. Map of Opol, Misamis oriental.

Sampling Frame

The sampling was conducted over a period of three (3) months from February to April 2016, which is considered as *Amihan* (Northeast Monsoon) in the Philippines. The water quality indicators such as relative humidity (RH), air and water temperature, Dissolved Oxygen (DO), pH, Density, Conductivity, Total Dissolved Solids (TDS),Turbidityand Salinity were tested on site while samples for Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS)were brought to the laboratory for analysis.

Samples brought at the laboratory were stored at 4°C and analyzed within 24-hr of collection Sampling was done from 7AM to 10AM once per week for three months, and results were done in monthly basis.

Physicochemical analyses

The marine water samples were examined for air temperature and relative humidity using Lutron, density water temperature using Anton Paar Alber. Dissolved Oxygen (DO) was also tested on site using Oakton, pH with Extech Oyster, Conductivity and Total Dissolved Solids (TDS) using Lutron, LaMotte turbidity meter for Turbidity, and France Refractometer for Salinity.

Data Analysis

The GIS map was employed using ARC GIS 10.2 software. Using the results obtained from the month of February to April, the physicochemical values were interpolated in an inverse distance weighting (IDW) to predict values of unmeasured location within the boundary area.

Thus, repeated measures analysis of variance was used to find out if the physicochemical values were significant between subjects (sites) and within subjects(trials/observations) and one-sample t-test was used to determine the significance of the mean of some parameters to the standards set by DENR Administrative Order no. 34.

Results and Discussion

GIS-Based Distribution Maps of Physicochemical Analysis of Water

In order to prioritize an area for conservation and asses protected area networks, Geographic Information System (GIS) is used to establish maps for species richness and endemism (Peterson *et al.* 2000). Fig. 2 and 3 (a-l), presents the distribution of physicochemical values obtained from the average months of February, March and April.Most predictive models had a quantitative relationship between organisms and its environment. Similarly, these particular models presented indicate habitats that are suitable and unsuitable for a target species, community and biodiversity as pointed out by Engler *et al.* (2004). Parameters such as RH, air and water temperature, density, turbidity, salinity, and total suspended solids (a,b,e,f,i,j,k) were prevalent in site 3 (recreational).

These results are attributed to the presence of resorts and hotel nearby that have contributed to the increased values in site 3. Likewise, the results are substantiated by the studies made by Salomon and Dross (2013) that, human activities in a marine ecosystem affects fisheries, land-based industries and tourism.Meanwhile, dissolved oxygen (c) had recorded with higher concentration distribution in site 1 (residential) and site 3 (recreational).

These results show an optimum level for good growth and can result to higher yield for fish population. An increased was observed in both sites which may have due to mechanical activities such as the use of boats and vessels and presence of aquatic plants and algae (Lawson, 1995). Biochemical oxygen demand on the other hand, had recorded with higher distribution in site 1 (residential) and site 2 (commercial). BOD is often used in wastewaters as the strength of waste in which the BOD is greater; the more concentrated its waste (Penn *et al.* 2006).

This explains to residential where locals uncono-sciously dispose garbage within the surroundings that might have carried along the shoreline and in commercial area where construction sites and restaurants might have contributed to the aforementioned waste. However, only pH values were recorded high in site 1 (residential), although high level was recorded among the three sites, values were within range where seawater range nearly to pH 8.3. Thus, optimum pH is usually between pH 7.5 and 8.5 for most marine animals since, they cannot tolerate the wide range of freshwater species with a pH of 6.0-9.0 (Boyd, 1998). Moreover, total dissolved solids has the highest distribution in site 2 (commercial) where on-going construction sites, restaurants and public highway was located.

According to Weber-Scannell and Duffy (2007), water is considered as “brackish” when water concentration exceeds 1000 mg/L or ppm, as a result of effluent discharges from point and non-point sources which may have changed the hydrological balance of water and its salt-water intrusion.

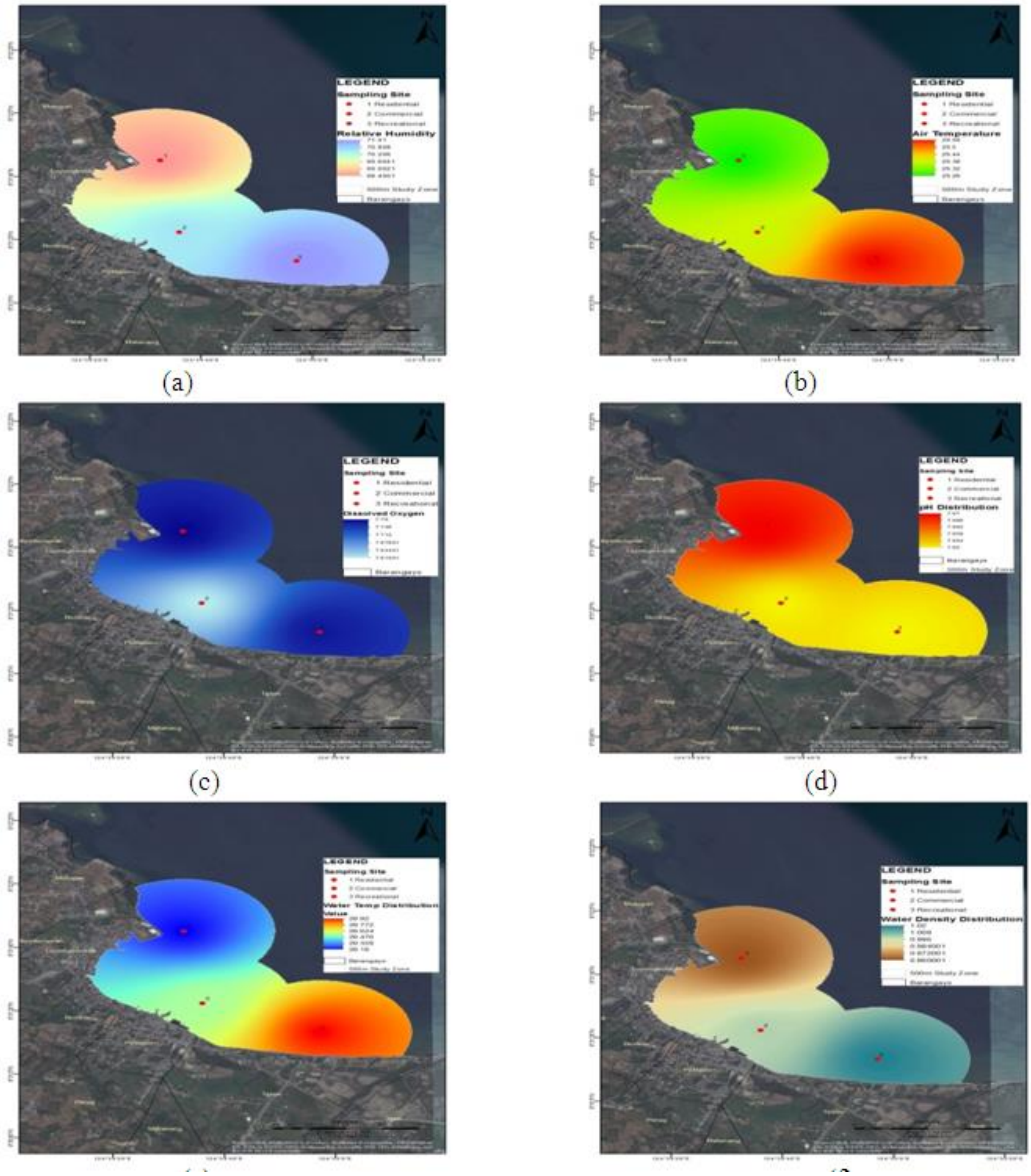

Fig. 2. GIS-based distribution maps of physico-chemical analysis in residential, commercial and recreational sites of Opol, Misamis Oriental. a. relative humidity, b. Air temperature, c. dissolved oxygen, d. pH, e. water temperature, f. density.

Water Quality Index of Marine Water

As the results shown in Table 1 on the three sampling sites of Opol, Misamis Oriental, values were obtained from the month of February to April 2016. Resulted values of relative humidity ranges from 62.80-69.38%, indicate a drier and warmer ambient from the months of March and April. The results may have affected to increase the temperature making the surroundings warm.

Studies made byThom (2013) on Climatology, if RH is computed to discomfort index, this gives an idea on the degree of discomfort felt by the people as it increases. Site 3 (recreational) from the month of March recorded with highest value on dissolved oxygen at 8.14 mg/L. This result indicates large amounts of oxygen available for bacteria to dissolve oxygen levels for decomposition.

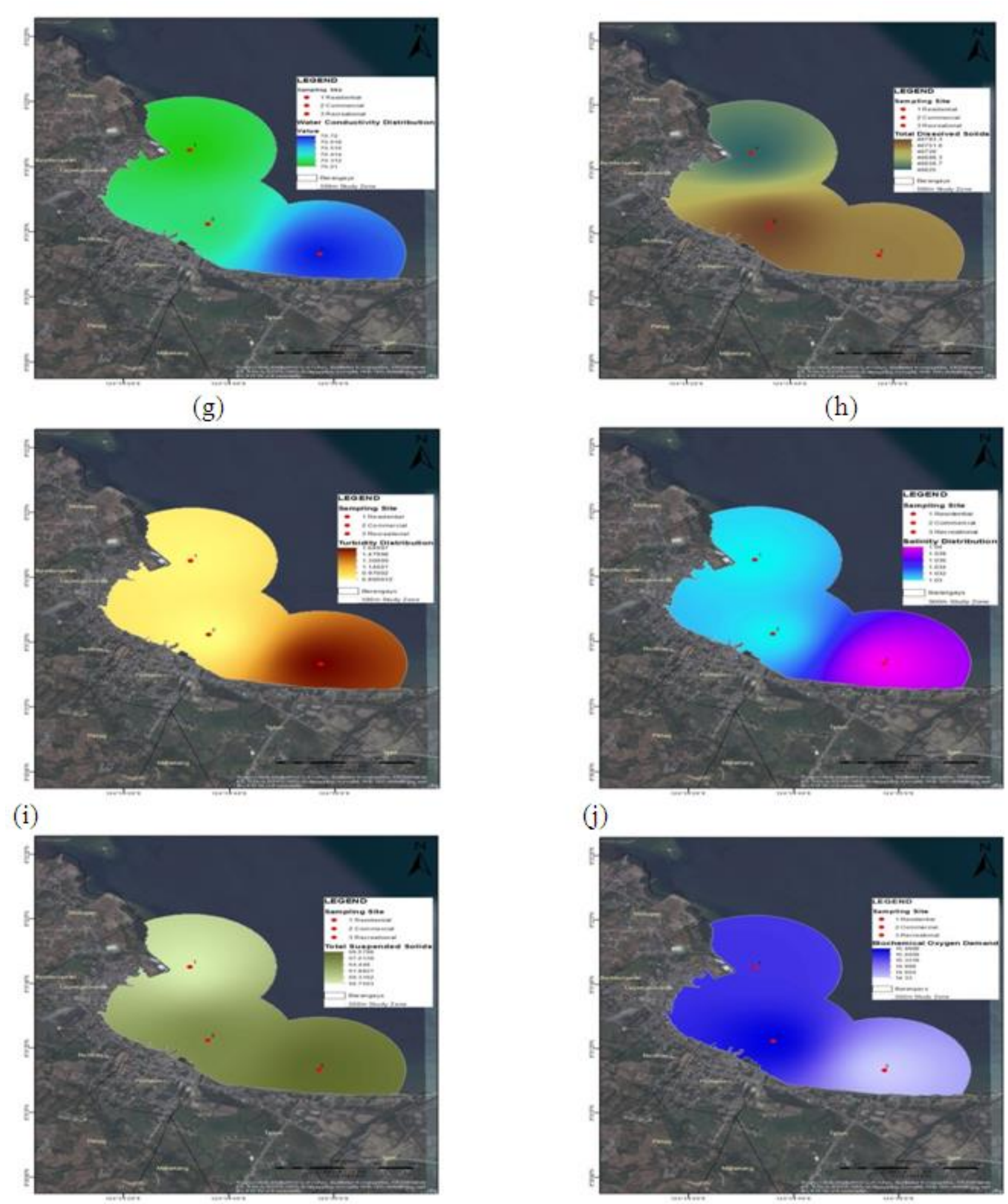

Fig. 3. GIS-based distribution maps of physico-chemical analysis in residential, commercial and recreational sites of Opol, Misamis Oriental. g. conductivity, h- total dissolved solids, i. turbidity, j. salinity, k. total suspended solids, l. biochemical oxygen demand.

However, site 1 (residential) and site 2 (commercial) of month April, low levels of DO was recorded, which provides insufficient demands for essential functions, or worst, suffocation to many aquatic organisms (Kramer, 1987).

Meanwhile, during decomposition of organic matter, the pH of recent marine sediments fairly remains and rarely exceeds the limits of pH 7.0 to 8.2, despite there were vast amounts of protolytic species that were being added.

Thus, values of pH from site 1, site 2, and site 3 averages from 7.95 to 7.97, which were found to be within range. Furthermore, it is evident that the pH of seawater increases as CO_2 increases. Hence, processes such as increasing the total alkalinity and production of ammonia may be counter balanced to remain a fairly constant pH (Yaakov, 1993).

Although temperature and density plays an inverse relationship, but positively related with salinity, site 3 has been recorded with increasing values at 1.035%. Increasing temperature affects the volume to increase by expansion, which may cause the density to increase as well. From the studies made by Walton (1989), typical conductivity values for seawater ranges from 40,000-60,000 µS/cm (40-60 mS) at 25°C, but values shown in Table 1 were higher, considering it as brine water type which range values from 60,000 µS/cm and above (60 mS/cm above) at 25°C. In addition to that, conductivity was theoretically related with TDS, where mixture of various salts and increasing total salt concentration becomes greater due to the interaction of both physical and electrical ionic.

Furthermore, water contaminants may have contributed to the increased levels of TDS. According to Tong and Chen (2002), as the water carries residue from the land, this may enriched with sediments and nutrients, thus modify the water's temperature, balance, land surface characteristics and its hydrological properties (LeBlanc *et. al.*1997). Despite of the increasing values of TDS, turbidity remained low, in which Kirk (1985) emphasizes, that turbidity is the intense scattering of light by fine particles, which appears to have low visual clarity and could not be compared with dissolved solids. Based from the related studies conducted by Bilotter and Brazier (2008), with the enhanced concentration of turbidity coming from point and non-point sources, this could alter the physical (such as temperature change and reduced penetration of light), chemical (such as heavy metals, pesticides and nutrients) and biological properties. Among the three sites of Opol, Misamis Oriental, site 2 was recorded to have high BOD levels from the average months of the study. BOD is the required amount of oxygen by aerobic organisms to measure the strength of wastes and stabilize polluted water (Marske and Polkowski, 1972). Therefore, there is alarming since the bacteria consume the available oxygen in the water. Hence, critical shortage of oxygen can lead to fish kills and deplete dissolved oxygen levels (Ryan, 1991).

Table 1. Physicochemical analysis of Marine water from the month of February to March on site 1 (Residential), site 2 (Commercial), and Site 3 (Recreational) of Opol, Misamis Oriental.

		SITE 1 (Residential)				SITE 2 (Commercial)				SITE 3 (Recreational)			
Parameters	Unit	FEB	MAR	APR	AVE	FEB	MAR	APR	AVE	FEB	MAR	APR	AVE
Relative humidity	%	74.36	68.05	62.80	68.40	76.45	69.38	65.76	70.53	77.12	69.08	68.03	71.41
Air Temp	°C	27.8	29.52	30.5	29.26	27.8	29.67	30.7	29.38	28.2	29.71	30.8	29.56
Dissolved Oxygen	mg/L	8.10	8.09	7.15	7.78	7.59	8.10	7.15	7.61	7.87	8.14	7.32	7.77
pH	mole/L	7.99	7.94	7.98	7.97	7.99	7.89	7.96	7.95	7.98	7.90	7.96	7.95
Water Temp	°C	27.8	29.4	30.3	29.18	28.5	29.7	30.4	29.54	28.6	30.7	30.5	29.92
Density	g/mL	1.0183	1.0214	0.9551	0.9983	1.0145	1.0209	0.9598	0.9984	1.0215	1.0154	1.0161	1.0177
Conductivity	mS	69.9	70.4	70.3	70.21	69.7	70.7	70.5	70.31	70.2	70.6	71.4	70.72
Total Dissolved Solids	ppm	46742	46000	47133.33	46625	46533.33	47008.33	46808.3	46783.33	46700	47125	46416.67	46747.22
Turbidity	ntu	0.76	1.20	0.54	0.83	1.06	0.77	0.56	0.80	1.22	1.68	2.05	1.65
Salinity	sg	1.035	1.034	1.035	1.035	1.034	1.034	1.035	1.034	1.036	1.034	1.035	1.035
Total Suspended Solids	mg/L	42	37	91.25	56.75	67.5	57.5	73.5	66.17	58.8	54.25	95.75	69.58
Biochemical Oxygen Demand	mg/L	16	18.75	12	15.58	13.5	23.75	10.75	16.00	13.75	17.5	11.75	14.33

H_o (b): The physicochemical parameter readings on the three sites are equal.
H_o (w_1): The physicochemical parameter readings on the three observations/trials on the same site are equal.
H_o (w_2): There is no interaction effect between the trials and site.

Comparison of Physicochemical values to DAO 1994-34

Out of twelve (12) water quality index or parameters used in this research, five (5) were identified to fall within the criteria of DENR Administrative Order no. 34. As shown in table 2, Philippines standards were used to determinewhetherthe value are set within limits in the three (3) sites which average from the months of February, March and April. Based from the values that were recorded, DO and BOD exceeded the set standards in which averages ofboth values among the three sites were higher than the criteria that were used in the standard set by Philippines.

Table 2. Standard set by DENR Administrative Order no. 34.

Parameters	Unit	Site 1	Site 2	Site 3	Philippines
DO	mg/L	7.78	7.61	7.77	5
pH		7.97	7.95	7.95	6.5-8.5
Water Temp	°C rise	29.18	29.54	29.92	3 °C rise
TSS	mg/L	56.75	66.17	69.58	< 30% increase
BOD	mg/L	15.58	16	14.33	5

Source; Philippine- DAO 1994-34.

To compare to the significant difference between the aforementioned sites to the values set by DENR Administrative order no. 34, one-sample t-test analysis (The full result is available in Appendix A) was employed. With respect to reference stress level, onesample t-test is used to compare three measured stress levels (de Winter, 2013). H_o is stated as the means of the observed parameters in residential, commercial and recreational and the standard are equal. According to Siegel (1957), there is no alternative to using a nonparametric statistical test if the samples are as small as 6, except if the population distribution is exactly known. Based from the parameters used, the associated probabilities are greater than 0.05, therefore, H_o is not rejected. Hence, residential, commercial and recreational and the standards are equal and statistically not significant.

Aside from the values compared with DAO 34, some parameters used in the study showed significant difference *between subjects* and *within subjects* at $p < 0.05$ level using repeated measures of analysis of variance. According to Everitt (2014), by reducing error variability and/or as a natural way of assessing certain phenomena, researchers should adopt the repeated measures paradigm. This gives rise to between subject and within subject factors.Between subjects indicate the three sites which are residential, commercial and recreational, while within subjects served as the trials or observations made on every site.

The results from the repeated measures analysis of variance (The full result is available in Appendix B) revealed significant differences existed on relative humidity, DO, pH, water temperature, conductivity, and turbidity readings in terms of sites and the trials made. The test of between-subject effects (site) showed that the F-value of 6.78 (relative humidity), 6.19 (DO), 3.63 (pH), 3.813 (water temperature), 3.475 (conductivity), 17.035 (turbidity) and 5.660 (salinity) are significant at 0.05 level. The probability associated with the occurrence of F-values as large as the observed F under H_o is less than 0.05. Thus, the null hypothesis that the relative humidity, DO, pH, water temperature, conductivity, turbidity and salinity reading with respect to sites are equal is rejected.Thus, the tests of within-subjects effects (set of observations/trials) revealed significant differences existed on the three sets of observations (trials) on the same site. The F-value which is equal to 46.73 (relative humidity), 33.37 (air temperature), 71.25 (DO), 11.188 (pH), 31.863 (water temperature), 7.34 (conductivity), 5.870 (TDS), and 2.679 (turbidity) are significant at 0.05. However, there is no interaction effect between the site and the observations (trials) at 0.05 level. Hence, the null hypothesis that the relative humidity, air temperature, DO, pH, water temperature, conductivity, TDS and turbidity readings on the three observations/trials on the same site are equal is rejected. However, in the interaction, the H_o is not rejected.

Conclusion

Geographic Information System (GIS) is an effective tool to asses an area for possible marine ecosystem studies and baseline tool for generating maps on the distribution of species, that will be used for future conservation and protection of area. Although, residential area was commonly known to have contributed primarily on the increased values of the result due to human activities, ordinances and penalties of the municipality gave the locals a mindful implementation on the improper and segregation of waste disposal along the coastal area. Thus, the results of physicochemical parameters revealed that recreational area obtained highest values on most parameters used, this may have attributed to excessive recreational activities, since the sampling frame falls within the months of summer. DO and BOD on the other hand, implied that marine water has alarming values in which marine organisms are greatly affected with this sudden change. Moreover, on the trend of increasing population and urbanization in Opol, it is necessary to conduct periodic monitoring and evaluation of the marine water with multi-sectoral participation of LGUs, industries and local residents in the protection and management of the marine water.

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Appendix A

One-sample t-test Analysis

Table 3.Results on observed parameter of site 1 (Residential)

Parameters	Unit	Mean	Standard error	standard	t	p-value
Dissolved Oxygen	mg/L	7.7806	0.08456	7.78	0.01	0.992
pH		7.7903	0.00835	7.97	0.033	0.974
Water Temperature	°C	29.1778	0.2826	29.18	0.008	0.994
Total Suspended Solids	mg/L	56.7500	11.8955	56.75	0	1.000
Biochemical Oxygen Demand	mg/L	15.5833	2.1265	15.58	0.002	0.999

Table 4. Results on observed Parameter of Site 2 (Commercial)

Parameters	Unit	Mean	Standard error	standard	t	p-value
Dissolved Oxygen	mg/L	7.6119	0.0791	7.61	0.025	0.981
pH		7.9467	0.0146	7.95	-0.229	0.82
Water Temperature	°C	29.5389	0.2148	29.54	-0.005	0.996
Total Suspended Solids	mg/L	66.1667	12.9228	66.17	0	1.00

Biochemical Oxygen Demand	mg/L	16.0000	3.0000	16	0	1.000

Table 5.Results on observed parameter of Site 3 (Recreational)

Parameters	Unit	Mean	Standard error	standard	t	p-value
Dissolved Oxygen	mg/L	7.7747	0.0835	7.77	0.067	0.955
pH		7.9458	0.0097	7.95	-0.43	0.67
Water Temperature	°C	29.9222	0.2366	29.92	0.009	0.993
Total Suspended Solids	mg/L	69.5883	10.4877	69.58	0	1.000
Biochemical Oxygen Demand	mg/L	14.3333	2.2202	14.33	0.002	0.999

Appendix B

Repeated measures Analysis of Variance

Table 6. Results on Repeated Measures Analysis of Variance on RH, Air temperature, DO, pH, water temperature, Density, Conductivity, TDS, Turbidity, Salinity, TSS and BOD.

Parameters	*Opol, Misamis Oriental*	Sum of squares	df	Mean square	F	p-value
RH	Between subject					
	site	171.89	2	85.95	6.78*	0.003
	error	418.2	33	12.67		
	Within subject					
	observation	2051.98	2	1025.99	46.73*	<0.0005
	trial* site	54.67	4	13.67	0.62	0.648
	error (trial)	1449.07	66	21.96		
Air Temp	Between subject					
	site	1.68	2	0.84	0.39	0.68
	error	70.99	33	2.15		
	Within subject					
	observation	139.52	2	69.76	33.37*	<0.0005
	trial* site	0.45	4	0.11	0.05	0.995
	error (trial)	137.99	66	2.09		
DO	Between subject					
	site	0.66	2	0.33	6.19*	0.005
	error	1.76	33	0.5		
	Within subject					
	observation	15.54	1	15.54	71.25*	<0.0005
	trial* site	1.17	2	0.59	2.68	0.083
	error (trial)	7.2	33	0.22		
pH	Between subject					
	site	0.14	2	0.007	3.63*	0.038
	error	0.063	33	0.002		
	Within subject					
	observation	0.102	1	0.102	11.188*	0.002
	trial* site	0.009	2	0.004	0.494	0.614
	error (trial)		0.3	33	0.009	
Water Temp	Between subject					
	site	9.979	2	4.989	3.813*	0.32
	error	43.177	33	1.308		
	Within subject					
	observation	89.026	2	44.513	31.863*	<0.0005
	trial* site	4.886	4	1.221	0.874	0.484
	error (trial)	92.202	66	1.397		
Density	Between subject					
	site	0.01	2	0.005	0.929	0.405
	error	0.17	33	0.005		
	Within subject					
	observation	0.011	1	0.011	1.041	0.315
	trial* site	0.023	2	0.012	1.111	0.341
	error (trial)	0.346	33	0.01		
Conductivity	Between subject					
	site	5.407	2	2.703	3.475*	0.043
	error	25.673	33	0.778		

	Within subject					
	observation	13.244	2	6.622	7.346*	0.001
	trial* site	3.751	4	0.938	1.04	0.393
Parameters	**Opol, Misamis Oriental**	**Sum of squares**	**df**	**Mean square**	**F**	**p-value**
RH	Between subject					
	error (trial)	59.492	66	0.901		
TDS	Between subject					
	site	495740.741	2	247870.37	0.355	0.704
	error	23033888.89	33	697996.833		
	Within subject					
	observation	296851.852	1	296851.852	0.289	0.595
	trial* site	12070370.37	2	6035185.185	5.870*	0..007
	error (trial)	33926111.11	33			
Turbidity	Between subject					
	site	16.698	2	8.349	17.035*	<0.0005
	error	16.174	33	0.49		
	Within subject					
	observation	0.806	2	0.403	0.574	0.566
	trial* site	7.516	4	1.879	2.679*	0.039
	error (trial)	46.291	66	0.701		
Salinity	Between subject					
	site	2.23 E-5	2	1.11 E-5	5.660*	0.008
	error	6.50 E-5	3	1.97 E-6		
	Within subject					
	observation	1.61 E-5	1	1.61 E-5	3.178	0.084
	trial* site	2.84 E-5	2	1.42 E-5	2.795	0.076
	error (trial)	1.6764 E-4	33	5.08 E-6		
TSS	Between subject					
	site	1060.167	2	530.083	0.324	0.732
	error	14746.167	9	1638.463		
	Within subject					
	observation	9501.5	2	4750.75	2.987	0.076
	trial* site	2,361.33	4	590.333	0.371	0.826
	error (trial)	28631.833	18	1590.657		
BOD	Between subject					
	site	18.056	2	9.028	0.109	0.898
	error	748.25	9	83.139		
	Within subject					
	observation	447.722	1	447.722	0.3499	0.094
	trial* site	88.111	2	44.056	0.344	0.718
	error (trial)	1151.5	9	127.944		

*Significant at 0.05 level