Linear Correlation Analysis of Water Quality Data for Southern Shan State, Myanmar

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Abstract

The objective of this investigation is to estimate the current status of physical, chemical characteristics and metals' content of fresh water sources in some places of Shan State, Myanmar. The experimental analysis was done in URC, University of Yangon and ALARM Ecological laboratory at Kamayut Township, Yangon. The obtained results (physical and chemical parameters) and toxic metals' content dissolved in chosen water were listed and compared with drinking water quality guidelines provided by WHO and Indian Council for Medical Research (ICMR). Moreover, Pearson correlation relations between various water parameters were determined. The recorded results proved that water quality of three samples were excellent of grading "A" but sample-4 was very poor of grading "D". Therefore, local people should not drink this stream water (SSS-4) without treatment.

Keywords – fresh water, physical and chemical characteristics, water quality analysis, water quality indices (WQI), correlation coefficient (r)

1. Introduction

Among nature's three precious gifts to mankind, water is the best natural resources for us. As water is an essential need for living things including human beings to use in various purposes, the suitability of water must be tested and analyzed before using. Water quality analysis is to collect water samples and to measure water parameters we need using standards methods. In addition, all water sources and water bodies should be monitored regularly to determine whether they are in good health or not and managed properly better plan of good quality of water. We all rely upon very limited natural resource of fresh water for designated uses such as recreation, drinking, domestic, irrigation, agriculture and industries. The study areas are rural regions in where local people rely on surface water for their daily uses such as drinking, domestic and agriculture and therefore the quality of surface water (fresh water) is vital. In this investigation, surface water samples were collected from rural regions of Southern Shan State, Myanmar during second week of February, 2020 and were made analysis of some characteristics of water to assess the water quality. The purpose of this investigation was (i) to observe some water quality parameters like physical and chemical characteristics and toxic metals, (ii) to compare with drinking water standards set by Water Association such as WHO and ICMR whether the results are in compliance with rules and regulations, (iii) to develop water quality indices (WQIs) for the assessment of water quality and (iv) finally to evaluate correlation coefficients between these water quality parameters for study area.

2. Materials and Methods

This paper describes consideration to be used in determining the study sites before collecting water, general and specific procedures to be observed while sampling, methods for measurement of some water quality parameters in water laboratory, analysis of water quality and finally the correlation among the various water quality parameters of the surface water in this area. The procedures of the water quality analysis in this investigation were described as shown in figure (1).

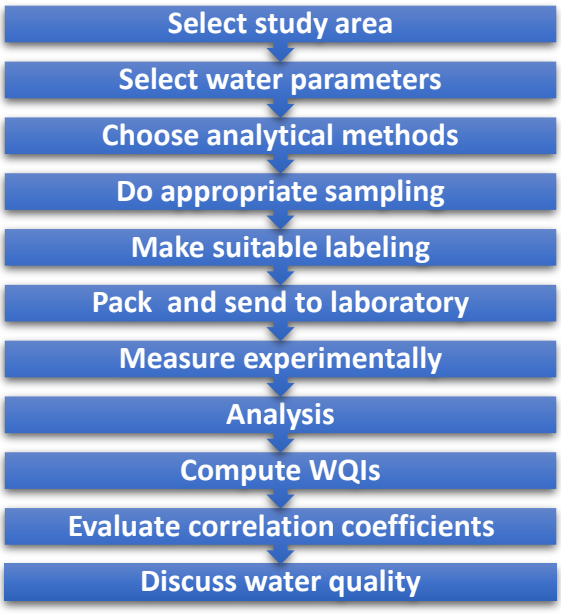

Figure 1. Procedures for water quality analysis

2.1. Study Area and Sampling Sites

For the present study, rural water sources from 4 different stations of two Districts of Southern Shan State, Myanmar were selected for water quality analysis. There are three districts such as Taunggyi, Loilem and Langkho in Southern Shan State, Myanmar. Among them, two districts, Loilem and Taunggyi, were

selected to collect water samples and analysed water quality. Sample-1 (SSS-1) was collected from lake situated at Pankan village, Pinlon. In this village, there is a coalmine. Sample-2 (SSS-2) was fetched from lake in Mong Pawn, Loilem District, Sample-3 (SSS-3) was collected from No (2) Pin Pet Steel Mill, Hopong, Taunggyi District and Sample-4 (SSS-4) was gathered from Taine Chaung Stream in Nanghu village, Nansang Township, Loilem District. The study areas involved various ethnics groups and also many traditional coal productions unlike Pin Pet Steel Mill. There are many shallow wells and streams in this area which are used as a source of water body for drinking purpose and domestic usage. Except sample-1 (SSS-1), the rest of water sample sources are now used as not only drinking water but also domestic uses.

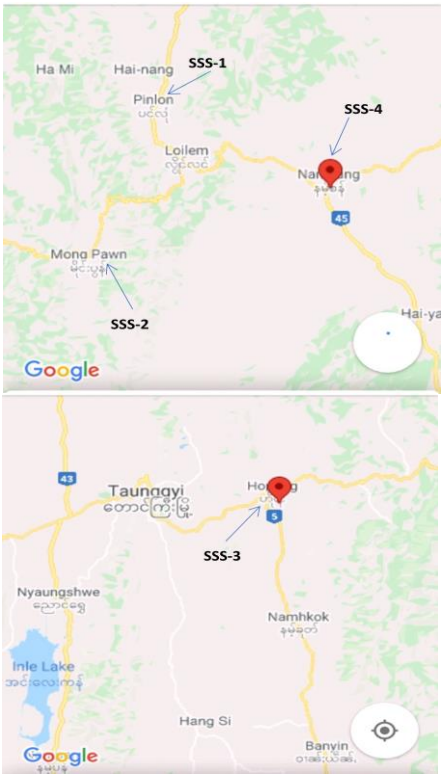

Figure 2. Study area and sampling sites in Shan state [5]

2.2. Analysis of Water Sampling

Before collecting water sample, polyethylene water bottles with caps were washed under the tap water and filled with 2 ml diluted chlorine water for one hour. And then, these bottles were slightly shaken and removed caps and made empty bottles. Water bottles and caps were rinsed under the flowing tap water until no foamed was seen. After that, three bottles including caps were rinsed with pure water. Finally, water sample bottles were dried at room temperature for a day. Before sampling, sterilized empty bottles were labeled with permanent marker not to rub off the written information. These dried bottles were packed with papers not to enter any effect including sunlight and brought to the area that is getting sample.

In getting sample water, water bubbles were not to be allowed during collecting water. After collecting water, bottles were screwed with caps immediately and tightly. Clean, dry and dark conditions must be needed throughout the transportation to the laboratory. Therefore, collected water sample bottles were put in a paper box, closed, and then labeled with sample information. Finally, four sample water bottles were carried to laboratory of University Research Centre, University of Yangon and ALARM Ecological Laboratory situated at Kamayut Township. The total time for sampling and transportation was within 2 days to obtain correct and definite values for water parameters.

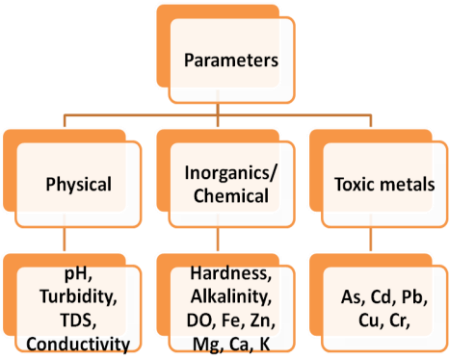

Figure 3. Parameters for water quality analysis

Table-1 Samples' parameters and laboratory methods of analysis
Source: Laboratory Survey.

Sr No	Parameter	Instruments	Methods / Descriptions
1.	pH	HANNA HI 98129, 98130 water proof pH tester	Electrode method
2.	Turbidity	Lovibond Spectro Direct	Lovibond Spectro Direct method No 385
3.	Total Dissolved Solids (TDS)	TDS meter	Electrode method
4.	Electrical Conductivity (EC)	HANNA HI 98129,98130 water proof EC tester	Electrode method
5.	Hardness	Lovibond Spectro Direct	Lovibond Spectro Direct method
6.	Dissolved Oxygen (DO)	DO meter	Electrochemical Probe method Dissolved Oxygen Probe measurement
7.	Alkalinity	Lovibond Spectro Direct	Lovibond brand reagent testing method
8.	As, Cd, Pb, Cu, Cr, Fe, Zn, Mg, Ca, K	PinAAcle™ 900H S/N PHCS16091301 atomic absorption spectrometer	Atomic Absorption Spectroscopy

All the water quality parameters were analysed according to standard methods for the analysis of water in two laboratories, Yangon. Analysed water parameters were distinguished into three portions namely (i) physical, (ii) inorganic/ chemical characteristics and (iii) toxic metals that were presented

in figure (3). In addition, comparison of the analysed parameters, designated instruments and used methods were systematically described in table-1.

2.3. Statistical Analysis

Pearson correlation coefficients (r) for four water samples were statistically determined to find the relationship between different water quality parameters for the water's characteristics. In computing WQI values, Weighted Arithmetic Index Method which was originally proposed by Horton (1965) and developed by Brown et al (1972) was used in this research paper. Standards of drinking water quality recommended by WHO which are universally accepted as the permissible values for the water-quality parameters are very important factors for all living things because the quality of water relates to the human health directly.

3. Results and Discussions

3.1. Physical Characteristics

Assessment of water quality in study area using some physical parameters to seek the status of water sources was reported in table-2. pH is very significant indicator to determine the status of water sources because water from four sampling stations had been used by local people in these areas for different purpose. According to analytical measurements, all pH values, turbidity data, total dissolved solids (TDS) and conductivities values for all water samples were consistent with guidelines for drinking water standard provided by WHO.

Table-2 Laboratory analysis of physical parameters compared with WHO standards, mean values and standard deviations [1][2][4]

Sr No	Parameters	Standard Values WHO (2011)	Measured Results Shan State					
			Sample-1	Sample-2	Sample-3	Sample-4	mean, $\bar{X}$	SD
1	pH	6.5-8.5	6.9	7.3	7.6	7.3	7.275	0.2872
2	Turbidity	<5	<5	<5	<5	<5	-	-
3	TDS	500	37	306	303	223	217.25	126.1649
4	Conductivity	2.5	0.07	0.5	0.5	0.4	0.3675	0.2039

3.2. Inorganic/Chemical Characteristics

According to the measured results of eight kinds of organic/chemical parameters, hardness for sample-3 (SSS-3) was higher than standard value but others were well below the limit. For alkalinity measurement, three samples were very larger than the ICMR standard except from sample-1 (SSS-1). Dissolved oxygen for sample-1 was 7.2 and sample-3 was 7.1, they were higher than ICMR limit. However, sample-2 and 4 had consistent values of dissolved oxygen under the standard. Due to the measured result of iron (Fe), three samples were nearly closed to WHO standard except sample-4 (SSS-4). Iron concentration of SSS-4 was 1.111 and it was higher than standard. For the rest of the chemical parameters, concentrations were well below the WHO standards for all samples by noting table-3.

Table-3 Measured values of inorganic/chemical parameters compared with WHO standards, mean values and standard deviations [1][2][4]

Sr No	Parameters	Standard Values WHO (2011)	Measured Results Shan State					
			Sample-1	Sample-2	Sample-3	Sample-4	mean, $\bar{X}$	SD
1	Hardness	200	12	56	319	9	99	148.2318
2	Alkalinity	120 (ICMR)	16	280	300	260	214	133.0063
3	Dissolved Oxygen	5 (ICMR)	7.2	1.38	7.1	3.5	4.795	2.854
4	Iron	1	0.964	0.968	0.965	1.111	1.002	0.0727
5	Zinc	3	0.168	0.162	0.191	0.163	0.171	0.0136
6	Magnesium	30	0.657	0.698	2.183	2.068	1.402	0.8375
7	Calcium	100	3.088	16.050	64.270	59.320	35.682	30.68
8	Potassium	100	0.043	0.719	ND	0.007	0.019	0.3517

3.3. Toxic Metals

Various metals can enter surface water (fresh water) and diffuse into the ground water due to the different sources such as either natural process or human activities. This event can make that surface water be contaminated or concentration of metals' levels in river water can be increased and toxic metals impact on human health. By noting the experimental results, concentration of cadmium (Cd), lead (Pb) and copper (Cu) were not detected and their contents were below the detective limits. Moreover, chromium contents for three samples were not detected except sample-4. Concentration of chromium (Cr) dissolved in sample-4 was 1.058 mg/L. The amounts of dissolved arsenic (As) for all samples were well below the WHO standard. All experimental results for (5) toxic metals were studied as shown in table-4.

Table-4 Experimental results of toxic metals' content compared with WHO standards, mean values and standard deviations [1][2][4]

Sr No	Parameters	Standard Values WHO (2011)	Measured Results Shan State					
			Sample-1	Sample-2	Sample-3	Sample-4	mean, $\bar{X}$	SD
1	Arsenic	0.01	0.00076	0.00095	0.00153	0.00134	0.00114	0.00035
2	Cadmium	0.003	ND	ND	ND	ND	-	-
3	Lead	0.01	ND	ND	ND	ND	-	-
4	Copper	2	ND	ND	ND	ND	-	-
5	Cromium	0.05	ND	ND	ND	1.058	0.256	0.5289

ND means non detective. All the toxic metals' levels were measured in mg/L.

3.4. Water Quality Analysis

Calculation of water quality index was carried out in this work by Weighted Arithmetic Index Method which was originally proposed by Horton (1965) and

developed by Brown et al (1972) to find the quality of surface water for drinking purpose. Using the following equation, the weighted arithmetic water quality index (WQI) is calculated.[3]

$$WQI = \frac{\sum_{i=1}^{n} W_i q_i}{\sum_{i=1}^{n} W_i} \quad \text{.....(1.1)}$$

In the first step, the value of quality rating or sub index (qi) is calculated according to Brown et al (1972) as follow:

$$q_i = 100 \left[\frac{measured\ values\ of\ i^{th}\ parameter - ideal\ value\ of\ i^{th}\ parameter}{standard\ value - ideal\ value}\right] \quad \text{.....(1.2)}$$

In the second step, the calculation of relative weight (W_i) of the parameters was carried out. The unit weight (W_i) which is inversely proportional to the values of the recommended standards is obtained as:

$$W_i = \frac{k}{S_i} \quad \text{.....(1.3)}$$

$$k = \frac{1}{\sum_{i=1}^{n}\left[\frac{1}{S_i}\right]} \quad \text{.....(1.4)}$$

Calculated water quality index of water samples is usually distinguished into five categories shown in table-5.

Table-5 Water quality indices (WQIs) and corresponding water quality status (C.Chatterjee and Raziuddin2002)[6]

WQIs	*Rating of Water quality*	*Grading*
0 - 25	*Excellent*	*A*
26 - 50	*Good*	*B*
51 -75	*Poor*	*C*
76 - 100	*Very poor*	*D*
> 100	*Unsuitable for drinking*	*E*

After comparison of standard values and measured variables, the values of water quality indices (WQIs) for all water samples were studied. Computational procedures for WQIs were discussed in this section. By studying table (7), WQIs for all water samples were within the range of grading "A" limited by C.Chatterjee and Raziuddin 2002 except sample-4. The WQI value of collected water for sample-4 was high due to the results of so high chromium concentration in present investigation. Among all water samples, the most value of WQI for sample -4 was 78.799 and the least WQI for sample-1 was 1.575.

Table-6 Computational results of (q_i) for surface water in study area

		Calculation of (qi) for water samples			
		Computed values (q_i)			
Sr No	Parameters	SSS-1	SSS-2	SSS-3	SSS-4
1	pH	6.67	20	40	20
2	Turbidity	-	-	-	-
3	TDS	7.4	61.2	60.6	44.6
4	Conductivity	2.8	20	20	16
5	Hardness	6	28	159.5	4.5
6	Dissolved Oxygen	77.083	137.708	78.125	115.625
7	Alkalinity	13.333	233.333	250	216.667
8	Arsenic	7.6	9.5	15.3	13.41
9	Cadmium	-	-	-	-
10	Lead	-	-	-	-
11	Copper	-	-	-	-
12	Cromium	-	-	-	2116
13	Iron	96.4	96.8	96.5	111.1
14	Zinc	5.6	5.4	6.367	5.433
15	Magnesium	2.19	2.327	6.943	6.893
16	Calcium	3.088	16.05	64.27	59.32
17	Potassium	0.033	0.553	-	0.00538

Table-7 Computational results of water quality indices (WQIs) for surface water in study area.

		Calculation of WQI for collected water samples			
		Computed values (w_iq_i)			
Sr No	Parameters	SSS-1	SSS-2	SSS-3	SSS-4
1	pH	0.00141147	0.00423228	0.008465	0.00423228
2	Turbidity	-	-	-	-
3	TDS	2.6621E-05	0.00022016	0.000218	0.00016045
4	Conductivity	0.00201457	0.01438977	0.01439	0.01151181
5	Hardness	5.3962E-05	0.00025182	0.001434	4.0471E-05
6	Dissolved Oxygen	0.02773016	0.04953965	0.028105	0.04159542
7	Alkalinity	0.00019977	0.00349611	0.003746	0.0032464
8	Arsenic	1.36702776	1.7087847	2.752043	2.41208451
9	Cadmium	-	-	-	-
10	Lead	-	-	-	-
11	Copper	-	-	-	-
12	Cromium	-	-	-	76.1218618
13	Iron	0.17339668	0.17411617	0.173577	0.19983787
14	Zinc	0.00335761	0.0032377	0.003817	0.00325748
15	Magnesium	0.00013131	0.00013952	0.000416	0.00041329
16	Calcium	5.5544E-05	0.00028869	0.001156	0.001067
17	Potassium	4.566E-07	7.6515E-06	-	7.4439E-08
	WQIs	1.57540591	1.95870423	2.987367	78.7993088

3.5. Correlation Analysis

In the present study, the correlation coefficient (r) between measured water parameters in evaluated was shown in table-8. The correlation coefficient (r) points that positive and negative relation of different variables with each other. The value of r = +1 means perfect positive correlation and r = -1 means perfect negative correlation. The value of "r" is closed to zero that points no linear relation between two variables. If "r" value is positive, one variable increases, and then the

other variable also increases and if the value of "r" is negative, first variable increases but other variable decreases.[7]

Table-8 Correlation coefficients (r) of various water quality parameters studied from Southern Shan State [7]

	pH	TDS	EC	Hardness	DO	Alkalinity	Arsenic	Cromium	Iron	Zinc	Magnesium	Calcium	Potassium
pH	1												
TDS	0.89	1											
EC	0.90	0.99	1										
Hardness	0.79	0.54	0.51	1									
DO	-0.11	-0.51	-0.52	0.44	1								
Alkalinity	0.92	0.98	0.99	0.49	-0.49	1							
Arsenic	0.89	0.66	0.69	0.7	0.12	0.76	1						
Cromium	0.06	0.03	0.11	-0.4	-0.3	0.23	0.37	1					
Iron	0.07	0.05	0.12	-0.41	-0.32	0.25	0.37	0.25	1				
Zinc	0.61	0.27	0.25	0.95	0.69	0.25	0.16	-0.39	-0.40	1			
Magnesium	0.74	0.45	0.49	0.56	0.22	0.6	0.24	0.53	0.53	0.55	1		
Calcium	0.82	0.58	0.62	0.57	0.09	0.71	0.25	0.51	0.51	0.52	0.99	1	
Potassium	0.01	0.42	0.38	-0.23	-0.78	0.28	-0.11	-0.35	-0.33	-0.46	-0.60	-0.47	1

Noting table-8, pH had strong positive relationship with total dissolved solid, conductivity, hardness, alkalinity, arsenics, magnesium and calcium. Total dissolved solid showed strong positive linear relationship with conductivity and alkalinity. Electricity conductivity was highly correlated with alkalinity (r = + 0.99). In addition, hardness was strongly correlated with zinc (r = + 0.95). Alkalinity proved positive linear relationship with arsenic and calcium. Moreover, magnesium was said to be a perfect relationship with calcium (r = + 0.99). Only dissolved oxygen had strong negative relation with potassium (r = -0.78).

4. Conclusion

By studying the whole investigation, there was very small variation in the physical, inorganic/chemical characteristics and concentration of toxic metals for surface water samples compared with guidelines for drinking water quality (WHO) and ICMR. The observed values of WQI range from 1.575 to 78.799 for four sampling points in two District of Southern Shan State. These WQI values indicates clearly that surface water getting from two lakes and surface water collecting from small stream flowing from the hills are showing towards an excellent water but the stream water of sample-4 is pointing towards a huge potential hazard for the local people due to excessive chromium, toxic element, and also iron content for sample-4 is in higher range than WHO permissible limit. From the findings of this research, the residents within the area of using water (SSS-4) must not drink without any treatment.

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