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Gasoline Station Spillage: Its Effect on Ground Water

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Abstract

This study aimed to determine the effect of gasoline station spillage on the ground water of the 3rd District Municipalities of Cagayan. Specifically, it determined the practices of Gasoline Stations; the pathogenic or coliform organisms through bacteriological parameters which are found/present in the ground water; the concentration of Total Dissolved Solids; and other chemical constituents through physico-chemical analysis present like lead or zinc. It also compared the physico-chemical and bacteriological parameters of the 3rd District Municipalities of Cagayan. Lastly, it spelled out remedial measures undertaken by the Gasoline Stations to minimize or avoid spillage. The study revealed that refilling service is expected to be the service most availed in gasoline stations. This is attributed to the fact that gasoline stations are really intended for refilling of diesel and gasoline products. The other services are just side services offered by the gas stations. The waste storage practices of the gasoline stations are still traditional as indicated by the ways in which their waste is disposed. Most of the total dissolved solids of the different gasoline stations in the 3rd district Municipalities of Cagayan are within the tolerable level set by PNSDW. Total hardness and chloride content of the ground water of the different gasoline stations are all within the tolerable amount. In terms of sulfate content, 61.71 percent are within the tolerable amount while 35.92 percent are beyond the tolerable amount. The ground water of the different gasoline stations contains more iron than manganese. They also contain traces of lead at approximately less than 0.05 parts per million of lead (<0.05). Likewise, significant difference was observed when the chloride content was compared with the different municipalities. While E. coli result is not significantly different when compared with the different quantitative parameters. The same was observed when compared with the waste disposals. Spillage can be minimized by the gasoline stations if they keep their waste in proper disposals.

Key Words: gasoline spillage, ground water

Introduction

Water provides for use in homes, for industries, for irrigation, for extinguishing fires, for street cleaning, for carrying wastes to treatment facilities and for many other purposes. The three most important factors in any water supply are its quality, the quantities available, and the location of the water supply relative to the points of use.

Water is the major constituent of living matter. Fifty (50) to ninety (90) percent of the weight of living organisms is water. Protoplasm which is the basic material of living cells, consists of a solution in water of fats, carbohydrates, proteins, salts and similar chemicals. Water is absolutely an essential substance because of its many uses such as a solvent for many substances, for cooking purposes, for irrigating farmlands and most of all for drinking. The new challenge facing the water supply profession is the control and removal of hazardous contaminants like bacteria, viruses, protozoans and other chemical substances which are unwanted to water.

The quality of water is ascertained by various kinds of analysis such as physical, chemical and bacteriological. Physical analysis consists merely of comparisons of the given samples with standard relations and the data relative to temperature, turbidity, odor and color. Chemical analysis indicates the time of past contamination and the nature of its origin-animal or vegetable, and the content of mineral salts. Bacteriological analysis was used to ascertain the absence or presence of the growth of colonies which cause bad taste and odor. Such analysis is capable of showing the number of potable origin of the bacteria present, but in matters of differentiation, as in the case of the typhoid germ from the harmless water bacteria, their operation is quite uncertain.

Water used for drinking must be free from pathogenic organisms responsible for waterborne diseases which consist bacteria, viruses, protozoan's and helminthes. Above all, it must not contain any substance like organism, chemicals or radioactive materials at a level or concentration which would endanger the health and lives of the consuming public.

The properties of pure water must be odorless and tasteless liquid. It has a bluish tint, which may be detected. Water is one of the best-known ionizing agents because most substances are soluble in it. Water combines with certain salts to form hydrates. It reacts with metal oxides to form acids. It also acts as catalyst in

many important reactions. It is for these reasons that the researcher is interested in studying the effect of gasoline spillage on the ground water of the 3rd district Municipalities of Cagayan.

Objectives of the Study

This study aimed to determine the effect of gasoline station spillage on the ground water of the 3rd District Municipalities of Cagayan .

Specifically, it aimed to:

1. Determine the practices of the Gasoline Stations' waste disposal in the 3rd District Municipalities of the of Cagayan that resulted to the physico-chemical and bacteriological contaminants.
2. Analyze the concentration of Total Dissolved Solids .
3. Determine and analyze other chemical constituents through physico-chemical analysis that are present like lead or zinc.
4. Determine the presence or absence of pathogenic and coliform organisms through bacteriological parameters in the ground water.
5. Determine if there is a significant difference in the physico-chemical-bacteriological parameters of the ground water in the in the erea.
6. Suggest remedial measures can be undertaken by the Gasoline stations to minimize or avoid spillage.

Research Methodology

This study was limited on physico-chemical and bacteriological test. Permission from the proprietors of the gasoline stations was asked before the collection of samples .After which, questionnaires were distributed and interviews were conducted. Analysis were done at the department of Science and Technology and other parameters were conducted at Cagayan Valley Medical Center and at the Mines and Geosciences Bureau in Quezon City Philippines.

Experimental Procedures

A. Bacteriological Parameters

Multiple Tube Fermentation Technique (MTFT)

Test for the Coliform bacili was conducted in three stages: the presumptive, the confirmed test and the completed test.

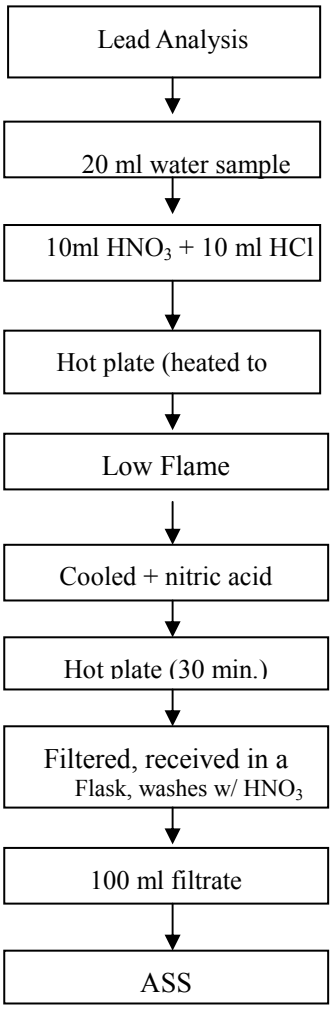
B. Physico-Chemical Parameter

Sampling for Physical and Chemical Analysis

A liter of ground water sample were collected from each gasoline stations in the 3rd district Municipality of Cagayan sufficed for most physico-chemical analysis and were brought to the laboratory for analysis.

Methods

1. Total Dissolved Solids **2. Sulfate Content** **3. Total Hardness**
4. Chloride Content **5. Manganese Content** 6. **Iron Content**
7. **pH** **8. Analysis of Lead Using Atomic Absorption Spectrometry Method**



F*ig. 1*. Flow Chart on Lead Analysis Using Atomic Absorption Spectrometry

Treatment of Data

Frequency in percent was used on the different parameters while analysis of variance (ANOVA), Least Significant Difference (LSD) and chi-square were used to determine significant differences on the physico-chemical and bacteriological parameters of the ground and the level of lead on their ground water.

Results and Discussions

A total of seventeen (17) gasoline stations were included as samples in the study. From the seventeen (17) gasoline stations, five (5) are under Shell and Petron company, four (4) from Caltex, one (1) from Total and two others are on Tingi basis. All the seventeen (17) gasoline stations are refilling stations. The following services are also offered by the gasoline stations in the 3rd District Municipalities of Cagayan; four (4) stations servicing battery charging, three (3) stations servicing change oil, two (2) stations servicing car wash , and three (3) gasoline stations, each of which offers only one of the following like clutch and wheel aligning, tune-up and greasing.

The frequency distribution of the services offered by the gasoline can be gleaned from the table below. The table reveals that among all the services offered, refilling service ranks first followed by battery charging, change oil, car wash, clutch and wheel aligning, tune up and greasing, respectively.

Refilling service is expected to be the service most availed of in gasoline stations. This is attributed to the fact that gasoline stations are really intended for refilling of diesel and gasoline. The other services mentioned are just side services.

Table 1. Frequency distribution of the services offered by the different stations

SERVICES	F	Rank
Refilling	17	1
battery charging	4	2
Change oil	3	3
car wash	2	4
clutch and Wheel Aligning	1	5
Tune up	1	5
Greasing	1	5

The seventeen (17) gasoline stations admitted that they have wastes. It was found out that from the seventeen (17) gasoline stations, 47.06 percent throw their wastes anywhere, 41.18 percent have their wastes in open pit, and 5.88 percent each stored their wastes in a tank and drum. This indicates that gasoline stations are not aware on the effects of their wastes on the environment and on the health of the people. However their wastes according to them are just minimal since they themselves are minimizing it for economic reasons. None of the respondents answered they are treating their wastes with chemicals or any other means or method of treatment.

The waste storage practices of the gasoline stations indicate that there are no waste storage system as indicated by the ways in which their wastes are disposed.

Physico-chemical Analysis

Total Dissolved Solids

Total Dissolved Solids (TDS) have important effects on the taste of drinking water. The palatability of water with Total Dissolved Solids level of less than 600 mg/L is generally considered to be good. Drinking water becomes increasingly unpalatable at Total Dissolved Solids levels greater than 1200 mg/L. Water with extremely low concentrations of Total Dissolved Solids may be unacceptable because of its flat, insipid taste or tasteless taste. The total dissolved solids in rivers are generally between 20 and 2,000 parts per million (ppm) and may be even higher in groundwater (Philippine National Standard for Drinking Water)

Table 2. Frequency Distribution in Percent of Total Dissolved Solids of Water Samples

Total dissolved Solids (mg/L)	Frequency	Percentage
600 and above	3	17.65
500	2	11.76
400	1	5.88
300	1	5.88
200	2	11.76
100	8	47.06
Total	**17**	**100**

Results in Table 2 show that gasoline stations with six hundred milligrams per liter and above value of total dissolved solids is 17.65 percent followed by 11.76 percent each with TDS value of five hundred and two hundred milligram per liter and 5.88 percent each for TDS value of four hundred and three hundred and 47.06 percent for TDS value of one hundred milligram per liter. The high content of Total Dissolved Solids may be due to the type of pipes that the gasoline stations had used, the way the structures were constructed and also the location of the ground water source. These factors may affect the TDS of the ground water.

Sulfate (SO_4^{-2})

Results in on the sulfate content of the seventeen (17) gasoline stations are still within the tolerable level of 250mg/L set by the Philippine National Standard for Drinking Water. The percentage distribution of sulfate content ranging from two hundred fifty mg/Land above is 35.9 percent, 17 percent for sulfate content of two hundred mg/L and 47.06 percent for one hundred milligram per liter sulfate content. The sulfate content of the ground water is just within the lower threshold level and would not alter the taste of drinking water. The high concentration of sulfate is indicative of some forms of pollution and can have adverse effects to human.

However, sulfate is one of the least toxic anions which no health-based guideline value has been derived (Philippine National Standards for Drinking Water, 1993).

Water Hardness

Water can be classified as either hard or soft water. Water containing dissolved calcium and magnesium salts or ferrous ion in amounts greater than 120 mg/L is considered hard. Hard water forms scale, a deposit of carbonate salts on the inner surfaces of boilers, cooking utensils and pipes that carry hot water or steam. Mineral salts precipitate the fatty acids from soap in the form of scum or a gelatinous curd (Grolier Encyclopedia of Knowledge, 1998).

Results on Total Hardness reveals that those with one hundred fifty one milligram per liter and above has a percentage of value of 17.65 percent, value of one hundred one mg/L to one hundred fifty mg/L has a percentage of 82.35 percent and none has a Total Hardness value of one hundred mg/L and below. The total hardness of the Ground water is tolerable and minimal as compared to the Philippine Standard for Drinking Water which means that they are safe to drink.

Chloride Content

Chloride content is minimal in all ground water of the gasoline stations as compared to the Philippine National Standards for Drinking Water which is 250 mg/L. The highest chloride content is registered at 160 milligram per liter which is below the tolerable value of 250 milligram per liter. Chloride in drinking water originates from natural resources, sewage and industrial effluents, urban run off and saline intrusion. Thus, among the gasoline stations surveyed, the highest chloride content is Shell (Solana) which may be due to its location where it is surrounded by a plywood company and rice and corn fields.

Table 3. Frequency Distribution in Percent of Chloride content of the Ground Water of the Gasoline Stations

Chloride content	Frequency	Percentage
150 - 200	2	11.76
100-149	3	17.64
50-99	4	23.53
Below 50	8	47.06
Total	17	100

Manganese (Mn^{+2})

Qualitative test for manganese content from the ground water of the gasoline stations (Table 4) showed the presence of moderate trace (++) violet coloration which has a percentage of 23.53 percent. Slight (+) traces of manganese were also observed and this has a percentage of 29.41 percent while absence (-) of manganese has a percentage value of 47.06 percent.

The presence of manganese interferes with laundering activities causing fabrics to turn yellow and cause difficulties in the distribution system by supporting the growth of microorganisms. (Philippine National Standards for Drinking Water, 1993).

Table 4. Frequency Distribution in Percent of Manganese of the Ground Water of the Gasoline Stations

Manganese Content	Frequency	Percentage
++	4	23.53
+	5	29.41
-	8	47.06
Total	17	100

Legend:

++ = moderate trace

\+ = slight trace

\- = negative

Iron Content

Qualitative test presented in Table 5 show that 23.53 percent of the gasoline stations are found to contain moderate trace (++) amounts of iron and all the other gasoline stations are found to have slight traces (+) of iron with a percentage value of 76.47 percent. Hence, the presence of iron in the ground water of the gasoline stations may lead to formation of iron coagulants, corrosion of steel and cast iron pipes during the distribution.

Table 5. Frequency Distribution in Percent of Iron of the Ground Water of the Gasoline Stations

Iron Frequency	Content(qualitative)	Percentage
++	4	23.53
+	13	76.47
Total	17	100

Legend:

++ = moderate trace

+ = slight trace

Hydrogen Ion Concentration (pH)

The pH frequency distribution in percent of the ground water of the seventeen gasoline stations (Table 6) has a percentage of 41.17 percent for a pH below seven while those with pH above seven constitute 58.82 percent. The pH value of the gasoline stations range from 6.5 to 8.2 which is within the pH range set by Philippine National Standards for Drinking Water.

The basic pH might be due to great deposition of hydroxide ions, bicarbonate and carbonate ions. However, the water source from Shell (Solana) and Caltex (Buntun) were found to be the most acidic which has both a pH of 6.5. This can also be due to the activities in the nearby water source. Although pH usually has no direct impact on consumers, it is one of the most operational water quality parameters. Careful attention to pH control is necessary at all stages of water treatment to ensure satisfactory water classification and disinfection. The pH of the water entering the distribution system must be controlled to minimize the corrosion in water main pipes in household water systems.

Table 6. Frequency Distribution in Percent of pH of Ground Water of Gasoline

pH Value	Frequency	Percentage
Below 7	7	41.17
7	0	0
Above 7	10	58.82
Total	**17**	**100**

Lead Content

Results from the analysis which is found on appendix table show that all the ground water of the gasoline stations in the 3rd District Municipalities of Cagayan are found to contain some amount of lead which is less than 0.05 parts per million (ppm). According to the Philippine National Standards for Drinking Water, 1993, potable water must not contain this heavy metal because it is toxic to human and other organisms in all forms.

Comparison of the Parameters

Results from Analysis of Variance show that there is no significant difference observed on TDS, sulfate, hardness, chloride content and pH as compared outside and within Tuguegarao. This means that the parameters are almost comparable with each other.

Furthermore, the T-values (Table 7) on sulfate, hardness and chloride content were of negative values because mean outside Tuguegarao is greater than mean within Tuguegarao, thus they contain more of these parameters as compared to the parameters within Tuguegarao.

Table 7. Comparison between Parameters Outside and Within Tuguegarao

Sources Of Variance	Mean Within Tug	Mean Outside Tug	t-value	df	P	Level of Significance
TDS	337.50	266.67	0.56	15	0.5805	ns
Sulfate	143.75	- 194.44	-1.53	15	0.1459	ns
Hardness	121.88	- 143.89	-1.79	15	0.0933	ns
Chloride Content	50.25	- 92.11	-1.99	15	0.0653	ns
pH	7.06	7.17	-0.42	15	0.6770	ns

Legend: ns = not significant

Analysis of Variance shows that there is no significant difference in the quantitative parameters; TDS, sulfate, hardness, chloride content and pH of the gasoline stations grouped by company. This result means that these quantitative parameters are almost the same with each other. Although among the parameters, the greatest F-value is observed on chloride content followed by hardness, sulfate, TDS and pH. It can be said that the variation among the parameters is not significant.

Table 8 which presents the comparisons among the parameters used grouped by Municipalities. Significant difference has been observed on chloride content in comparison with the different municipalities. This means, the chloride content is not comparable with the other parameters as observed on the f-value giving 3.675 which is the highest value observed. This shows that Chloride is due to the location of the groundwater source, the type of material and pipe used and its surroundings. No significant difference was observed when the gasoline stations were grouped by municipalities as compared to the quantitative parameters like TDS, sulfate, hardness and pH.

Table 8. Comparison among the parameters grouped by municipalities

Sources of Variances	SS Effect	df Eff-ect	MS Effect	SS Error	df Err-or	MS Error	f –value Error	P Error	Level of Signifi-ca nce
TDS	271250	6	45208.33	748750	10	74875	0.60	0.7227	ns
Sulfate	40606.6	6	6767.77	39637.5	10	3963.75	1.71	0.2173	ns
Hardness	6928.9	6	1154.81	4709.4	10	470.94	2.45	0.1008	*
Chloride	24479.6	6	4079.94	11100.5	10	110.05	3.675	0.034	ns
pH	0.7	6	0.12	3.1	10	0.31	0.40	0.8659	ns

Legend: ns = not significant

* = significant at 0.05

The least significant difference (LSD) of chloride content on the collected water samples from the different Municipalities involved in the study shows that water samples collected from Solana and Amulung are comparable in terms of chloride content. However, the chloride content of their water samples differed significantly when compared with other Municipalities. The presence of chloride in the water samples are high but it is within the tolerable level of chloride content as compared with the Philippine National Standards for Drinking Water which is 250 mg/L

Other municipalities when compared show no significant difference. This may be attributed to low content of chloride.

Table 9. Comparison of Means of Chloride content of different Municipalities

Municipalities	Tuguegarao mean=50.25	Enrile m=31.0	Iguig m=55.5	Tuao m=86.0	Penablanca m=75.5	Solana m=150.0	Amulung m=150
Enrile	0.5979						
Iguig	0.8460	0.5616					
Tuao	0.3356	0.2702	0.4720				
Penablanca	0.3603	0.3011	0.5617	0.8022			
Solana	0.0036*	0.0154*	0.0177*	0.1479	0.0493*		
Amulung	0.0181*	0.0301*	0.0431*	0.2042	0.0979	1.000	

Legend: * significant

ns =not significant

Bacteriological Analysis

Fecal coliforms are groups of coliform bacteria that are present in sewage disposals. The presence of fecal coliform bacteria indicates that a pathway exists from waste sources such as animal feedlot run-off, septic tank or espool leakage.

The data presented in Table 10 show that 58.82 percent have positive result with E. coli while 35.2 percent have negative result and an Arizona of has 5.88 percent was also obtained. Therefore water from gasoline

stations that have positive results with E. coli need to be treated while ground water that has Arizona result needs cleaning since the result is not positive with E. coli and is not of fecal origin. This indicates that there might be other contaminants found in the water while ground water samples that have negative result with E. coli is potable and safe to drink.

Table 10. Frequency Distribution in Percent of E. coli Result of Ground Water of Gasoline Stations

E. coli Result	Frequency	Percentage
+	10	58.82
-	6	35.29
Arizona	1	5.88
Total	17	100

Legend : + presence - absence

Table 11 compares the different parameters with the positive and negative result of the E. coli shows that there was no significant difference on the E. coli test. This indicates that the very minimal presence of E. coli on the different ground water source is not related with the different quantitative parameters. As shown in the table, E. coli and chloride content show the least difference. There are very minimal amounts of microbes present on the said parameter compared with the other parameters like TDS, sulfate, hardness and pH.

Table 11. Comparison between the Different Parameters with Positive and Negative Result of E. coli.

Parameters	Mean Positive	Mean Negative	t-value	df	p	level of significance
TDS	284.62	350	-0.44	15	0.6652	ns
Sulfate	161.54	200	-0.95	15	0.3589	ns
Hardness	130.77	142.5	-0.75	15	0.4647	ns
Chloride Content	72.15	73.25	-0.04	15	0.9691	ns
pH	7.10	7.175	-0.26	15	0.7992	ns

Legend : ns = not significant

As to the relationship between E. coli test result and waste disposal, it is noted in the Table 12 that there was no significant relationship between them. This suggests that the presence of E. coli may not be due to the wastes disposed or dumped near or within the vicinity of the ground water source but it would be more on the location of the ground water source nearing septic tanks and animal feedlot run-off.

Table 12. Test of Relationship between E. coli result and Waste Disposal

E. coli	Chi -square	df	p	Level of significance
E. coli versus waste Disposal	1.121	2	0.57096	ns

Legend: ns = not significant

Table 13 illustrates no significant difference between the parameters when grouped according to waste disposal. This means that sulfate, hardness and TDS were quite tolerable in terms of the cleanliness of the ground water samples collected at different gasoline stations in the 3rd district Municipalities of Cagayan. However, chloride and pH seem to affect the growth of microbes as seen in table below. It was noted from prior tables on wastes disposal and E. coli result that there is minimal presence of microbes which may also support Table 18 results.

Table 13. Comparison among the parameters grouped by wastes disposal

Sources of ofVariance	SS Effect	df Effect	MS Effect	SS error	df error	MS error	F	p	level of significance
TDS	10714.29	2	5357.14	100286	14	72091.84	0.07	0.9287	ns
Sulfate	6722.69	2	3361.35	73571	14	5255.1	0.64	0.5422	ns
Hardness	261.00	2	380.50	10877	14	776.95	0.49	0.6229	ns
Chloride	6880.90	2	3440.45	28699	14	2049.94	1.68	0.2221	ns
pH	0.65	2	0.33	3	14	0.23	1.42	0.2740	ns

Legend : ns = not significant

Remedial measures can be undertaken by the gasoline stations. To minimize or avoid spillage the following remedial measures should be undertaken; there should be proper treatment employed by the gasoline stations for their used oil before disposal. Furthermore spillage can be minimized if the gasoline station keep or disposed their waste properly. According to Manahan the wastes thrown to the environment can be minimized if proper disposal are being observed.

Conclusions

Based from the findings of the study, the following conclusions can be drawn:

The operations/services offered by the gasoline stations in the 3rd District of Cagayan do not result to the contamination of the ground water. Hence it can be stated that these parameters are similar throughout the country. This does not mean to say that we should not be vigilant of the practices of the gasoline stations because if we become unaware and neglectful on the activities of the gasoline stations this will eventually lead to contamination or pollution.

Recommendations

Based from the results of the study, the recommendations are that the physico-chemical and bacteriological analysis of the ground water of other municipalities of Cagayan should also be conducted and that the ground water of the gasoline stations which were found positive with E. coli be treated and immediate action be made by proper authorities. The ground water of the gasoline station which was found to contain Arizona result be taken into consideration by checking the pipelines if it has leakage which serves as entry of the microbial result. Another is that chemical analysis should be done on the chemical composition of gasoline to have a baseline data on their components if it really effect samples to be analyzed either soil or water. Lastly it is recommended that parallel studies should be conducted to test other parameters.

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