

The Status of Phosphate (PO_4^{3-}) Anion Concentration in Waste Water from Six Selected Undetermined Areas of Guyana using a Spectrophotometric Method

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ABSTRACT

Phosphates occur solely in waste water as Orthophosphates, Condensed or acid hydrolysed phosphates (Pyro, meta and ortho polyphosphates) and Organically bound Phosphate. Phosphate ion concentration from six selected areas of Guyana in the region of Berbice, Demerara and Essequibo was determined using Stannous Chloride, Molybdate Colorimetric, Spectrophotometric method. The applicable range of this method is 0.01 to 6 P/L. For each selected area, Phosphate ion concentration was determined at three locations: close to the discharge, 20ft and 40ft from the effluent. Accordingly, the highest concentration of phosphate occurs at the Demerara Distilleries Limited, DDL (Demerara), Industry (a residential area) and LaBonne Intention Sugar Factory (Demerara). These areas registered values of 6.078 ± 2.92 mg/L, 8.45 mg/L ± 1.53 mg/L and 7.062 mg/L respectively. The lowest concentration of 1.59 ± 0.01 mg/L and 0.882 ± 0.019 mg/L were registered at the Kingston Seawall and at the Canje River (GUYSUCO, Berbice) respectively. The UK Standard and the Caricom (1981 draft) for Phosphorus in potable water is 2.2 mg/L. The European Union (EU) maximum admissible concentration (MAC) of Phosphorus in Potable water is 5 mg/L. It seems that three of the six selected Guyana water are polluted with Phosphate anion above the threshold limit and the country waste water must therefore continued to be monitored as Industrialisation and development intensify.

Keywords: Phosphates, Orthophosphates, Condensed phosphates, Spectrophotometric, Selected Waste Water, Maximum admissible concentration (MAC).

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INTRODUCTION

This paper focuses on the determination of phosphates (PO_4^{3-}) anions in wastewater systems from six selected areas in the regions of Berbice, Demerara and Essequibo of Guyana, using an Ultraviolet Spectrophotometric method. The latter is applicable to the analysis of drinking, surface, domestic and industrial waters [1-3]. It can be modified to compensate for turbidity, colour, salinity and dissolved organic compounds in the sample.

Guyana has been described as the Land of many waters, but there is a need for an environmental water policy, especially in light of possible contamination of water resources that originates from industries, agriculture and households in areas that are heavily populated, NDS 1996 [4]. As industrialization and development intensify we need to know the status of our water. Some possible sources of environmental pollution in Guyana are:

- The tailings dam at LINMINE (Bauxite mining) in the town of Linden discharges decant water with a pH of 4.5, via the local stream, into the Demerara River.
- The release of mercury (Hg) via the washing process in small scale gold operations in the interior of Guyana.
- Sedimentation in the Berbice River from the canal at the Aroaima bauxite project.
- The use of "missile dredges" in the Essequibo River basin, which have had a devastating effect on the forest and river areas in which they operate, causing: destruction of river banks and pollution of rivers from the chemicals used in the extraction process and from the diesel fuel used to run the dredging machines. Such impacts on the Potaro River are threatening the pristine environment of the Kaieteur Falls, the only legally established protected area.
- Demerara Distilleries Limited waste being released into the Demerara river on a daily basis containing high concentrations of phosphates, nitrates, chlorides and calcium;
- GUYSUCO (Guyana Sugar Corporation) waste being disposed into the Canje creek and other rivers during the "in crop season".
- The sewage wastewater that released in the sea at the Kingston seawall.

There is no monitoring of the impacts of these wastes being released into our water bodies but the incidence of health problems suggests that improper management of wastes poses serious environmental and public health

problems nationwide. In addition, the agricultural runoff which ultimately enters the coastal zone may contribute potentially significant pollutants in the form of increased Biochemical Oxygen Demand (BOD) and nutrient enrichment. Such pollution have serious impacts on aquatic and marine life and any contamination of drinking water from this runoff would impact human health. Untreated industrial effluents discharged into nearby canals and rivers will affect the quality of drinking water if not rapidly dissolved. Table-1 shows the sources of possible Industrial Waste in Guyana [4].

Phosphate anion (1) is a salt of phosphoric acid, H_3PO_4 with empirical formula PO_4^{3-} . It consists of one central phosphorus atom surrounded by four oxygen atoms in a tetrahedral arrangements. The phosphate anion is a hypervalent molecule and incorporates phosphorus [5].

The Phosphate ion carries a negative three formal charge and is the conjugate base of the hydrogen phosphate anion, HPO_4^{2-} , which is the conjugate base of $H_2PO_4^-$, the dihydrogen phosphate ion, is the conjugate base of H_3PO_4 , phosphoric acid.

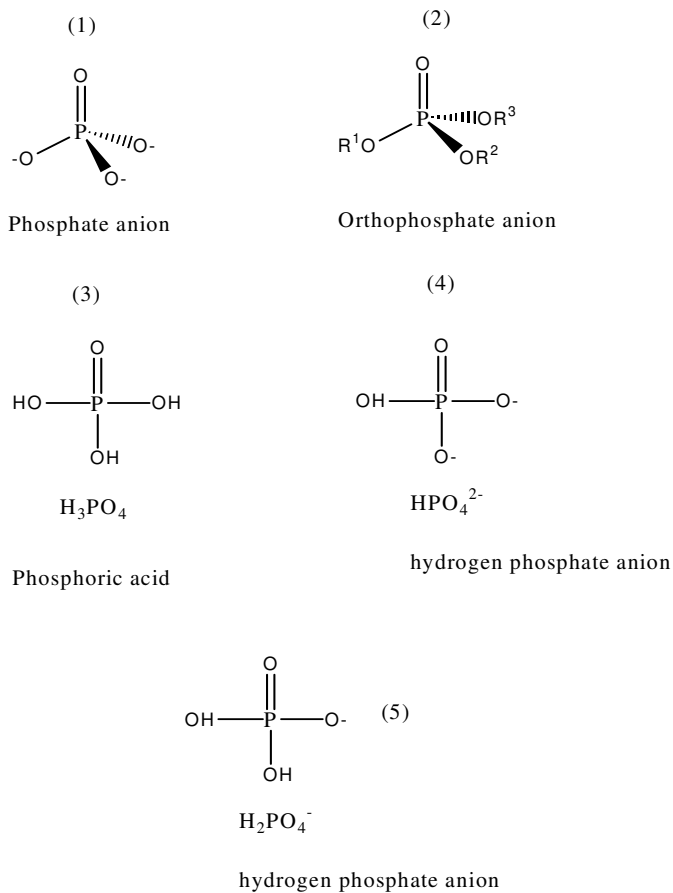


Fig.-1

Organophosphate (2), Figure -1, is an ester of phosphoric acid, H_3PO_4 . Phosphate can also form polymeric ion such as diphosphate (pyrophosphate, $P_2O_7^{4-}$, triphosphate, $P_3O_{10}^{5-}$ etc. Metaphosphate ions which are long linear polymers have an empirical formula of PO_3^- and are found in many compounds.

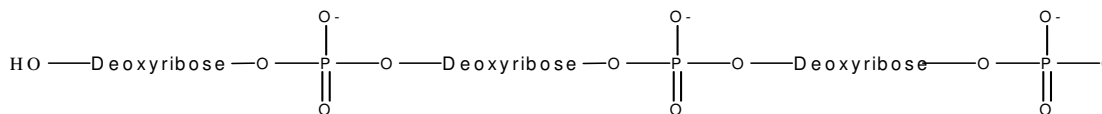


Fig.-2: Structure of Adenosine Triphosphate, ATP, (a) and a section of a single strand of DNA.

Biologically, Phosphates are found in the form of Adenosine Phosphates (AMP, ADP and ATP) and in DNA and RNA, Figure 2. Hydrolysis of these results in the release of phosphates. Phosphates are useful as buffering agents in the Biological system. These include Na_2HPO_4 , NaH_2PO_4 and the corresponding potassium salts. Phosphates form the structural material of bone and teeth [6].

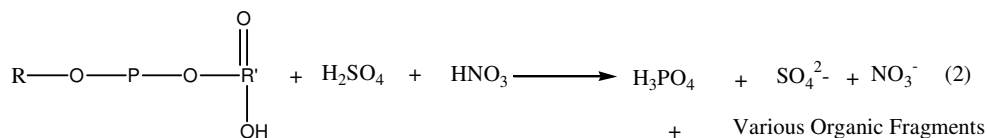
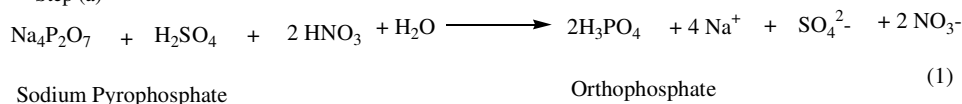
Phosphorus in phosphates is essential for the growth of plants, animal and microorganisms. It is an essential part of the process of photosynthesis and can be the nutrient that limits the primary productivity of a body of water. In instances, where phosphate is a growth-limiting nutrient, the discharge of raw or treated wastewater, agricultural drainage, or certain industrial wastes to that water may stimulate the growth of photosynthetic aquatic micro and macro-organisms in nuisance quantities. Phosphorus is involved in the formation of all oils, sugars, starches etc. It helps with the transformation of solar energy into chemical energy, proper plant maturation, withstanding stress and it also encourages blooming and root growth [1-3].

Phosphates anion occurs in natural and wastewaters as Orthophosphates, Condensed or acid hydrolysed phosphates (Pyro-, meta-, and other polyphosphates), and organically bound phosphates. They occur in solution, in particles or detritus, or in the bodies of aquatic organisms. These forms of phosphate arise from a variety of sources. Phosphates may also occur in bottom sediments and in biological sludge. Orthophosphates, condensed phosphate and organically bound phosphate all together are referred to as the "Total Phosphorous." content . The determination of total phosphorous content involves two steps:

- (1) The conversion of condensed and organically bound phosphate to soluble orthophosphate by acid oxidation;
- (2) Spectrophotometric determination of Phosphorous (P) in the soluble orthophosphate.

The chemical equations that govern the reaction are as follows:

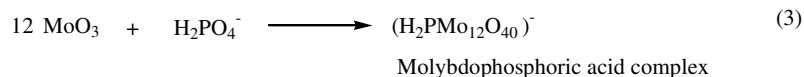
Step (a)



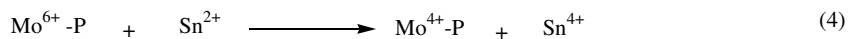
R and R' = various organic groups

Step (b)

Formation of Molybdophosphoric acid (Mo-P) complex



Reduction of Mo in the Mo-P complex by Sn^{2+}



Blue- coloured complex
Scheme-1

Acid oxidation is achieved via digestion of the sample with H_2SO_4 and HNO_3 (Equations 1 and 2) and the soluble Orthophosphate was measured Spectrophotometrically at 660 NM via the Molybdenum (Mo) Blue method using

Stannous (ii) chloride, SnCl₂ as a reducing agent (equation 3 and 4) reduced the Molybdophosphoro acid complex to the Blue coloured Mo⁺-P complex. Interfering substances/factors include high iron concentrations that can cause precipitation of and subsequent loss of Phosphorous.

The applicable range of this method is 0.01 to 6 P/L. This method is limited by possible high concentration of iron that can cause precipitation of and subsequent loss of phosphorus[1-3]. Also, the sample colour that absorbs in the photometric range used for analysis. Sample colour that absorbs in the photometric range used for analysis will also interfere.

Table -1: Sources of Industrial Waste in Guyana, National Development Strategy, NDS, 1996.

INDUSTRY	POTENTIAL POLLUTANTS
Sawmills	BOD, dust
Food processing	BOD, phosphates, solids, dust, pathogens
Detergents/soaps	BOD, phosphates, caustics
Metalworking/foundry	Heavy metals, solids
Sugar refinery	BOD, solids, caustics, phosphates
Chemical/pharmaceutical	Acids, alkalies, phosphates, solids
Distilleries/breweries	BOD, phosphates, thermal
Plastics	CFCs, solids

Six selected areas of coastal Guyana were monitored. These were the Kingston Seawall (1), Demrara Distilleries Limited (2), DDL, Kuru Kuru Livelihood (3) (Interior, remote area), La Bonne Intention, GUYSUCO (Guyana Sugar Corporation Estate, Demerara) (4), Canje River (Berbice) (5), Industry Pipe H₂O (6). For each location, waste water was monitored at three different locations: near effluent, 20ft from effluent and 40 ft from effluent. To the very best of knowledge, the phosphate anion concentrations in these areas were never determined prior to this research.

The Guyana Government with help from the World Bank have constructed Sand filtration Water treatment plants along the inhabited coast of Guyana [7-8].

Table-2: List of areas monitored in Guyana

Key	Location
1a	Seawall (Kingston Area)- near effluent
1b	Seawall (Kingston Area)- 20 ft from effluent outflow
1c	Seawall (Kingston Area)- 40 ft from effluent outflow
2a	DDL run off- close to discharge
2b	DDL run off- 20 ft from effluent
2c	DDL run off- 40 ft from effluent
3a	Kuru kururu livelihood- first creek
3b	Kuru kururu livelihood- 20 ft from effluent
3c	Kuru kururu livelihood- 40 ft from effluent
4a	LBI Guysuco Estate
4b	LBI Guysuco Estate- 20 ft from effluent
4c	LBI Guysuco Estate- 40 ft from effluent
5a	Canje River (Guysuco)
5b	Canje River (Guysuco)- 20 ft from effluent
5c	Canje River (Guysuco)- 40 ft from effluent
6a	Industry Pipe Water

The Guyana Government with help from the World Bank have constructed Sand filtration Water treatment plants along the inhabited coast of Guyana [7-8] .

MATERIALS AND METHODS

Equipment

Conical flasks (250 mL), Measuring cylinders (100 mL), hot plate, volumetric flasks (50 ml, 100 mL, 1L), UV-VIS Spectrophotometer, Filter paper; Whatman # 541, 11.0 cm.

Reagents

H₂SO₄ (conc.), H₂SO₄ (10%), HNO₃ (conc.), H₂O₂ (30%), Blue Litmus paper, NH₃ Solution (1:3; v/v), Ammonium molybdate- (NH₄)₆MO₇O₂₄.4.H₂O

Procedure

Ammonium molybdate- (NH₄)₆MO₇O₂₄.4.H₂O was prepared as follows

1.4L of H₂SO₄ (conc.) was added to 3L of distilled H₂O, slowly, with stirring. This was allowed to cool to room temperature. A wide-mouth vessel was used for preparing this acid solution!! 125g (41.67 g) of (NH₄)₆MO₇O₂₄.4.H₂O was dissolved in 250mL of the acid solution, and was carefully mixed with the rest of the acid solution. It was then transferred to a 5 L flask and diluted to mark, shaken well and stored in a dark bottle to prevent photolytic decomposition.

Stannous chloride, SnCl₂.2H₂O

30 ml HCl (conc.) was added to 220mL of distilled H₂O, slowly stirred, then boiled. It was then removed from heat and 7g of stannous chloride (SnCl₂.2H₂O) was added. This was heated until the solution was clear and when cool, it was made up to 250mL volume with distilled water. Mineral oil (paraffin oil) was added and stored in a dark bottle.

Standard stock solution (Potassium dihydrogen phosphate) (1000mg/L P)

4.3942g KH₂PO₄ was dissolved in 500mL of distilled water in a 1L volumetric flask. It was then diluted to mark with distilled water and mix thoroughly.

Digestion of samples and Reference solution

100 mL of the sample was transferred to a 250mL conical flask. 10mL of 10 % H₂SO₄ was added and sample was digested to 50mL. After digestion it was cooled, then 10mL of conc. HNO₃ was added and samples were further digested to 5mL. Dark samples were cleared up by adding 30% H₂O₂ drop-wise. Three sample blanks were also prepared. 100mL of the reference solution was digested using the same procedure. These were transferred quantitatively to a 100mL volumetric flask using the Whatman Filter paper (# 541, 11.0 cm). Particulate material or turbidity was removed by this filtration. Sample was then diluted to mark with distilled water and was well stirred.

A small piece of blue litmus paper was added to each aliquot. The paper changed to a red colouration. NH₃ solution (1:3) was then added until the red litmus paper changed to blue. 10% H₂SO₄ was added again until the blue litmus paper changes back to red. The Spectrophotometer was turned on and allowed to warm up for at least 15 minutes.

Phosphate Standard

A 100mg/L Phosphorous standard was prepared by transferring 10mL of 1000mg/L stock standard to a 100mL volumetric flask, then diluting to mark with distilled water which was then mixed thoroughly. 5mL of this solution was transferred to a 100mL volumetric flask and diluted with distilled water to give a 5 mg/L P standard. 1,2,3,4 and 5mL each was pipette from the 5 mg/L P standard into 50mL volumetric flasks, and was finally diluted to mark. These volumes gave standards of 0.1,0.2,0.3,0.4 and 0.5 mg/L P. 20mL of distilled water. 2mL of Ammonia Molybdate, (NH₄)₆MO₇O₂₄. 4H₂O solution and 4 drops of Stannous chloride (SnCl₂) solution were added to the samples, blanks, reference solutions and standard above.

Dilution to mark was done with distilled water, and it was shaken vigorously to yield the blue coloured Mo⁴⁺-P complexes whose absorbance were measured at 660 nm using the UV-VIS Spectrophotometer. A smaller aliquot was used if absorbance were off-scale. A larger aliquot of sample was used when sample absorbance were less than the absorbance of the standard with lowest concentration.

RESULTS AND DISCUSSION

Calculations are in accordance with literature [1-3].

$$\text{Corrected or True Absorbance} = \text{Total absorbance of the sample (TA)} - \text{Absorbance of the blank (AB)} \quad (5)$$

When the spectrophotometer is in absorbance mode,

$$P, \text{ the concentration of the phosphate anion (mg/L)} = (\text{Abs}_{\text{TA}} - \text{Abs}_{\text{AB}}) \times \text{Dilution Factor} \times \text{MIS} \quad (6)$$

Where:

Abs_{TA} = Absorbance of sample and reference solutions i.e Total absorbance

Abs_{AB} = Absorbance of blank solution,

MIS = Mean Inverse Slope given by

$$\text{Mean of: } \frac{\text{Conc. of each standard}}{\text{Abs of each standard}} \quad (7)$$

If instrument is in concentration mode

Using corrected absorbance, Phosphate ion concentration is calculated using the formula-

$$P \text{ (mg/L)} = \frac{\text{Corrected Absorbance} - 0.0125}{0.371} \tag{8}$$

Corrected Phosphate ion concentration is calculated using

$$P \text{ (mg/L)} = \text{Corrected Conc. Reading} \times \text{Dilution Factor} \tag{9}$$

The UV/VIS Spectrophotometer was in concentration mode, thus the corrected concentrations of Phosphorous in mg/L was determined using equation (9).

The average absorbance of the blank for the six areas monitored are as follows:

Table-3

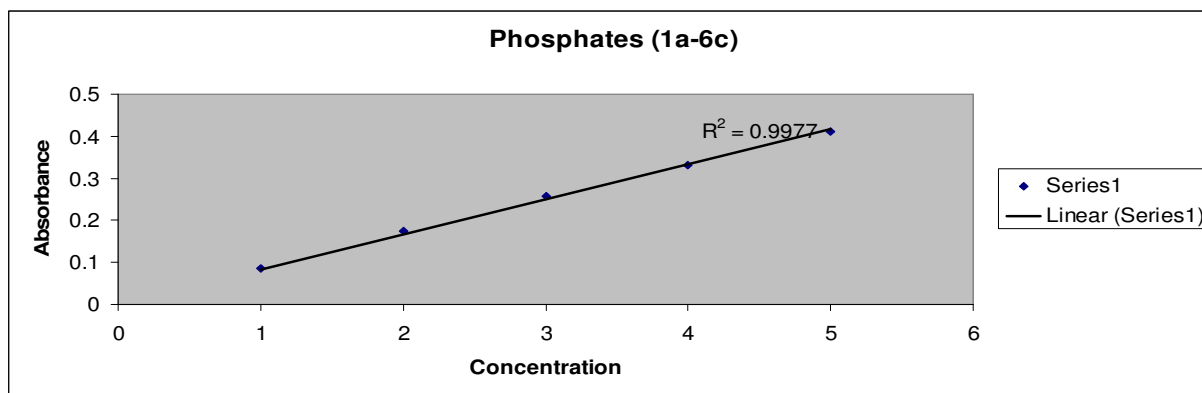
Sample Area	Average Absorbance of Blank
1	0.02
2	0.55
3	0.55
4	0.02
5	0.42
6	0.42

Keys: 1: Seawall (Kingston), 2: DDL, run-off, 3: Kuru kuru Livelihood, 4: LBI GUYSUCO Estate: 5: Canje River, 6: Industry Pipe water

Three sets of standards were prepared for each of the six concentrations and the average absorbance taken.

Table-4: The following table shows the concentration and absorbance of the phosphate standards where the concentration was determined using the formula: $P \text{ (mg/L)} = \text{Concentration Reading} \times \text{Dilution Factor}$

Total Phosphorus (Phosphates)		
No	Concentration (mg/L)	Absorbance
1	0.1	0.086
2	0.2	0.176
3	0.3	0.256
4	0.4	0.332
5	0.5	0.412



Graph-1: The following graph shows the concentration versus absorbance of the standards of concentration 0.1, 0.2, 0.3, 0.4, and 0.5 mg/L phosphorous.

The UV_VIS Spectrophotometer was in concentration mode, thus the concentrations of phosphorous in mg/L was determined using the following equations (8) and (9).

Table-5: The Table below shows the results obtained for the analysis of phosphates after computation using formula (4) – (5)

Blank	0.023							
No.	Corrected Absorbance	Absorbance	Weight (ml)	Dilution factor	Calculated concentration	Corrected concentration	Average (mg/L)	Standard deviation (±)
1a	0.132	0.155	0.1	5	0.32	1.61		
	0.13	0.153	0.1	5	0.32	1.58		
	0.13	0.153	0.1	5	0.32	1.58		
	0.131	0.154	0.1	5	0.32	1.59	1.59	± 0.013
1b	0.219	0.242	0.1	5	0.56	2.78		
	0.14	0.163	0.1	5	0.34	1.72		
	0.137	0.16	0.1	5	0.34	1.68		
	0.212	0.235	0.1	5	0.54	2.69	2.22	± 0.60
1c	0.283	0.306	0.1	5	0.73	3.65		
	0.141	0.164	0.1	5	0.35	1.73		
	0.277	0.3	0.1	5	0.71	3.56		
	0.272	0.295	0.1	5	0.69	3.49	3.11	± 0.92
2a	0.099	0.122	0.1	5	0.23	1.17		
	0.073	0.096	0.1	5	0.16	0.82		
	0.075	0.098	0.1	5	0.17	0.84		
	0.092	0.115	0.1	5	0.21	1.07	0.97	± 0.17
2b	0.141	0.164	0.1	5	0.35	1.73		
	0.599	0.622	0.1	5	1.58	7.90		
	0.577	0.6	0.1	5	1.52	7.61		
	0.537	0.56	0.1	5	1.41	7.07	6.08	± 2.92
2c	0.429	0.452	0.1	5	1.12	5.61		
	0.459	0.482	0.1	5	1.20	6.02		
	0.457	0.48	0.1	5	1.19	5.99		
	0.445	0.468	0.1	5	1.17	5.83	5.86	± 0.56
BK 2	0.55							
3a	-0.435	0.115	0.1	5	-1.21	-6.03		
	-0.422	0.128	0.1	5	-1.17	-5.86	-5.93	± 0.51
	-0.425	0.125	0.1	5	-1.18	-5.89		
	-0.437	0.113	0.1	5	-1.21	-6.06	-5.96	± 0.09
3b	-0.418	0.132	0.1	5	-1.16	-5.80		
	-0.431	0.119	0.1	5	-1.19	-5.97		
	-0.431	0.119	0.1	5	-1.19	-5.98		
	-0.432	0.118	0.1	5	-1.19	-5.99	-5.94	± 0.09
3c	-0.441	0.109	0.1	5	-1.22	-6.11		
	0.44	0.99	0.1	5	1.15	5.76		
Blank	0.023							
No.	Corrected	Absorbance	Weight	Dilution	calculated	Corrected	Average	Standard

	Absorbance		(ml)	factor	concentration	concentration		deviation
	0.082	0.105	0.1	5	0.19	0.94	1.97	± 0.82
4a	0.209	0.232	0.1	5	0.53	2.65		
	0.137	0.16	0.1	5	0.34	1.68		
	0.207	0.23	0.1	5	0.52	2.62		
	0.152	0.175	0.1	5	0.38	1.88	1.51	± 0.25
4b	0.113	0.136	0.1	5	0.27	1.35		
	0.115	0.138	0.1	5	0.28	1.38		
	0.117	0.14	0.1	5	0.28	1.41		
	0.109	0.132	0.1	5	0.26	1.3		
4c	0.151	0.174	0.1	5	0.37	1.87		
	0.827	0.85	0.1	5	2.195	10.9	7.07	± 6.61
	0.927	0.95	0.1	5	2.46	12.3		
	0.146	0.169	0.1	5	0.36	1.79		
BK 3	0.42							
5a	0.08	0.103	0.1	5	0.18	0.91		
	0.078	0.101	0.1	5	0.18	0.88		
	0.077	0.1	0.1	5	0.17	0.87		
	0.077	0.1	0.1	5	0.17	0.87	0.88	± 0.02
5b	0.117	0.14	0.1	5	0.28	1.41		
	0.13	0.153	0.1	5	0.32	1.58		
	0.127	0.15	0.1	5	0.31	1.54		
	0.112	0.135	0.1	5	0.27	1.34	1.47	± 0.11
5c	0.087	0.11	0.1	5	0.20	1.00		
	0.093	0.116	0.1	5	0.22	1.08		
	0.095	0.118	0.1	5	0.22	1.11		
	0.097	0.12	0.1	5	0.23	1.14	1.08	± 0.06
6	0.477	0.5	0.1	5	1.25	6.26		
	0.707	0.73	0.1	5	1.87	9.36		
	0.727	0.75	0.1	5	1.93	9.62		
	0.647	0.67	0.1	5	1.71	8.55	8.45	± 1.53

Statistical Analyses
Standard Deviation

Standard Deviation, is calculated using
$$S = \sqrt{\frac{\sum_{i=1}^n (x - \bar{x})^2}{n-1}} \tag{10}$$

Where = \bar{x} is the item

\bar{x} is the mean; n is the total number of item

Variance

A variant is the square of the standard deviation,
$$S^2 = \frac{\sum_{i=1}^n (x - \bar{x})^2}{n-1} \tag{11}$$

Confidence interval at 95%

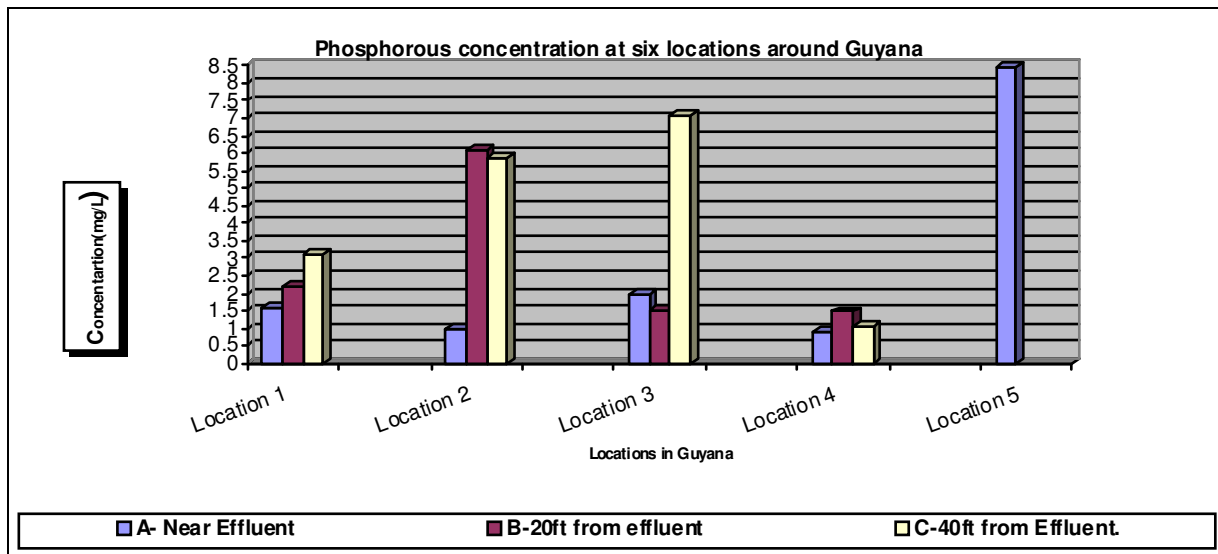
Confidence limit, CL (u) was calculated using the formula:
$$CL (u) = \bar{X} \pm z\sigma/\sqrt{N} \tag{12}$$

Where Z is a statistical factor related to the probability level required at the 90%, 95% or 99% and Z = 1.64, 1.96 and 2.58 at the three confidence levels respectively. Using the above formulae, Standard deviation, variance and the Confidence Limit were calculated and tabulated in Table-6.

Table-6: The following table shows the average, Standard deviations, variance and confidence at 95%, received from the phosphate data collected

No.	Average	Standard Deviation (±)	Confidence Limit	Variance
1a	1.59	0.013	1.59 ± 0.01	0.0002
1b	2.04	0.60	2.04 ± 0.59	0.36
1c	3.12	0.92	3.11 ± 0.90	0.85
2a	0.97	0.17	0.97 ± 0.17	0.03
2b	6.08	2.92	6.08 ± 2.86	8.52
2c	5.86	0.56	5.86 ± 0.55	0.32
3a	-5.93	0.51	-5.92 ± 0.49	0.26
3b	-5.96	0.13	-5.95 ± 0.13	0.02
3c	-5.94	6.82	-2.11 ± 6.69	46.6
4a	1.97	0.82	1.97 ± 0.81	0.68
4b	1.51	0.25	1.51 ± 0.25	0.06
4c	7.07	6.61	7.07 ± 6.48	43.7
5a	0.88	0.02	0.88 ± 0.02	0.00
5b	1.47	0.11	1.46 ± 0.11	0.01
5c	1.08	0.06	0.88 ± 0.02	0.003
6a	8.45	1.53	8.45 ± 1.49	2.342

Keys: 1: Seawall (Kingston), 2: DDL, run-off, 3: Kuru kuru Livelihood, 4: LBI GUYSUCO Estate: 5: Canje River, 6: Industry Pipe water



Graph-2: The graph below represents the concentration of phosphates for the different samples analysed for five regions at three different locations.

Location 1: The Kingston Seawall; Location 2: DDL Runoff; Location 3: GUYSUCO LBI Estate; Location 4: Canje Creek ; Location 5: Industry Pipe water

It is necessary to monitor waste water in Guyana so as to take measures to prevent the effects of phosphate and other anionic pollutants [9]. The largest source of phosphates discharge into surface water is usually via agriculture,

human sewage followed by detergents[9, 15, 16] . The discharge of phosphate along with nitrate into surface water are the main cause of Eutrophication. The latter results in excessive phytoplankton growth that starve marine life such as fish of O₂, resulting in death¹⁰. The input of phosphates into fresh water is also via erosion.

Phosphate ion concentration for the six selected areas of Coastal Guyana was determined using a Stannous Chloride Molybdate Calorimetric Spectrophotometric method as outlined in the introduction. The first step involves the conversion of condensed and organically bound phosphate ion in the sample to soluble Orthophosphate by acid oxidation using H₂SO₄ and HNO₃ and the second stage involves the spectrophotometric determination of phosphorus in the soluble Orthophosphate at 660 NM by the Molybdenum (Mo) Blue method using Stannous (II) chloride as the reducing agent. The applicable range of this method is 0.01 to 6 P/L. This method is limited by possible high concentration of iron that can cause precipitation of and subsequent loss of phosphorus [1-3] . Also, the sample colour that absorbs in the photometric range used for analysis.

Graph 1 was obtained when phosphates standard of 0.1, 0.2, 0.3, 0.4 and 0.5 mg/L were analysed for their absorbance using the Stannous chloride, Molybdate Calorimetric Spectrophotometric method and absorbance was plotted against concentration. According to the Standard plot, Graph 1, the concentration of phosphate, PO₄³⁻ anion increases linearly with increasing absorbance. Thus, the concentration of a sample could have been determined when the absorbance was acquired by identifying the relating concentration when a line was drawn from the acquired absorbance value to the line on the graph via the construction of a line from the required absorbance value to the line on the graph.

The concentration and corrected concentration (expressed in mg/L) of the phosphate anion was determined using formula (8) and (9) and was plotted against the regions to give Bar Graph 2. The concentration of samples were compared with the graph to ensure accuracy. This was proven to be true when the absorbance was lined up to the related concentration on the graph. For each absorbance, corrected concentration of the Phosphate anion, Standard Deviation, Variance and Confidence limits were calculated in accordance with literature [11,12] and these are presented in Table 6.0.

The UK Standard and the Caricom (1981 draft) for Phosphorus in potable water is 2.2 mg/L. The European Union (EU) maximum admissible concentration (MAC) of Phosphorus in Potable water is 5 mg/L. Phosphate ion concentration exceeded the International accepted value of 5mg/L at the following locations: 2b, Demerara Distilleries Limited, DDL run off, 20 ft from effluent (6.078 ± 2.92 mg/L), and at Industry, a Residential area (8.45 ± 1.53 mg/L). Another area of high phosphate concentration is at LaBonne Intention, Guyana Sugar Corporation (GUYSUCO) (7.0665 ± 6.6074 mg/L). Moderate concentration of 3.1098 mg/L also occur at 1b, Seawall, Kingston Area, 20ft from the effluent. The reason for the moderate Phosphate concentration at the Kingston seawall is probably due to the Communal sewage system that functions around our garden city (Georgetown, the capital). Millions of gallons of sewage fluids are being released into the ocean on a daily basis. This fluid is highly concentrated with phosphates which are eventually distributed to the rest of the water bodies. It is said that phosphorous from detergents make up to 47-65% of the total phosphorous in sewage from 6 English sewage works in 1971 compared with 10-20% in 1957 [13].

The highest concentration of phosphates ion at DDL run off, 20 ft from the effluent is due to the fact that DDL, a beverage company deals with drinks and food materials. DDL is the home of the World famous El Dorado rum. Many detergents are used to aid in washing up of bottles to be recycled together with other equipments that may be present in the Industry laboratories. Since this water is eventually being led to the Demerara River it causes the concentration of phosphorous in the Demerara River to also rise. High concentration of phosphate facilitates excessive growth of algae and excessive build up of corrosion of metal parts. Also, Eutrophication.

LBI (LaBonne Intention) waste water at 40ft from the effluent showed a significantly high concentration of phosphate ion, 7.0665 ± 6.6074 mg/L. This is because the main contributor of phosphates in these water bodies is due to the waste being released from the sugar factories in these areas. The high concentration of phosphate anion at LBI, GUYSUCO is probably due to phosphates that are expected to enter the water from fertilizers such as triple super phosphate, TSP as a result of tendering of the sugar canes. Losses of phosphates to water is equivalent to 60% of the fertilizer applied to the land are known[14]. Much of the phosphorous however is tightly bonded to soil particles and is not immediately biologically available when it reaches fresh water, but the solubility of phosphate is enhanced when the soil particles become incorporated into anaerobic mud.

Significantly low concentration of phosphates < 1 mg/L were registered at Kuru Kuru Livelihood, 3a, 3b, 3c. These values range from -5.96 to -5.93 mg/L. These are remote areas in the interior of Guyana where inorganic fertilizer is seldom used. Other areas of low phosphate ion concentration are Kingston Seawall, near effluent and Canje River (GUYSUCO), Berbice. These areas registered values of 1.59 ± 0.01mg/L and 0.88 ± 0.019 mg/L

respectively. The negative values obtained revealed that the phosphate concentration was too low to be detected. This was decided after repeating the test using both smaller and larger aliquots of the samples.

CONCLUSION

Phosphate anion concentration for six selected areas of Guyana was determined via the Stannous chloride Molybdate Spectrophotometric method. For three regions, value exceeded the internationally accepted standard of 5 mg/L for effluents from DDL, LaBonne Intention, LBI Sugar Factory and Industry residential area, East Coast Demerara. Values were also less than 1.5 mg/L for the other three areas determined: Kuru Kuru livelihood, Kingston Seawall and the Canje creek. Measures should thus be taken to ensure that there is a reduction in phosphate pollution for those three areas and Guyana waste water continued to be monitored as industrialisation and development intensify. Countries in which the level of phosphate has risen above the threshold values have seen measures implemented from the Government. For example the European Committee (EC) is looking to expand its ban on all but trace amounts of phosphates in household dishwasher detergents sold in EU by 2012[15-16].

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