Determination of the cyanide content in different water sources available to Dhaka

A project submitted

by

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Abstract

Cyanide is known as one of the deadliest chemicals in the world and has a notorious history including mass genocide. There are very few antidotes against it which only work at a low concentration of the poison. High exposure to this chemical has no reversal and not only leaves permanent damage to the body but is also fatal at most of the times. With the growing number of industries in Dhaka city especially in the plastic, paint and metal sectors which have been known to release cyanide into the environment, there are higher chances of cyanide pollution now more than ever. My work focuses on the cyanide concentration in water bodies such as rivers and lakes which are a dumping ground for chemical wastes and also a comparison of other water available to the people living in the city. My work includes a survey of the areas that contain water bodies suspected with cyanide contamination. Samples were taken from these water sources such as the main water body of the area, tap water supplied into the area and the tube well water pumped from the ground. Water samples were also collected from non-industrial areas within Dhaka city for a better comparison. The water samples were then tested for cyanide in the laboratory following EPA guidelines and quantified. The results were then compared with WHO and US EPA guidelines for cyanide limit in drinking water. Results were compared with the location and type of the area within Dhaka city. Results proved cyanide concentration to be within limits but industrial areas' to be very close to the borderline and at risk with the rapidly increasing number of industries every year.

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Chapter 1: Cyanide and its toxicity

1.1 What is cyanide poisoning?

Cyanide is a known toxin, popular for its utilization in mass crimes, suicides and a noteworthy war weapon. A fruity drink (Kool-Aid) bound with potassium cyanide was the reason for the mass suicide of the individuals from the People's Temple in Jonestown, Guyana, in 1978. The Nazis utilized cyanide as a weapon for mass genocide in the gas loads in World War II. There are conceivable methods for inadvertent cyanide introduction, for example, being stuck in a fire in an encased space or a working environment where cyanide is utilized as a manufacturing procedure. The atomic structure of cyanide comprises of a cyano group (carbon triple fortified with nitrogen) joined with elements like hydrogen or potassium. It can exist as a salt, liquid or gas. In the circulation system cyanide reacts with ferric particles, attaches to chemicals and meddles with enzymatic course responses, which at that point causes focal sensory system and cardiovascular degeneration. On account of cyanide poisoning medicinal services suppliers must be alert for associated harming and give prompt antitoxin for effective treatment.

As pointed out in table 1.1 cyanide has various natural, environmental, industrial and even household sources.

1.2 Sources of cyanide

Cyanide can be found in very common daily uses in our lives. Knowingly or not we are exposed to it regularly but the concentration of exposure is usually negligible and has no drastic effect of toxicity. But a sudden mass exposure is all it takes for fatal poisoning. The following table shows where cyanide is significantly used.

Table 1.1 Sources of cyanide

Industrial sources	• Insecticides
	• Photographic solutions
	• Metal polishing materials
	• Jewelry cleaners
	• Acetonitrile
	• Electroplating materials
	• Synthetic products such as rayon, nylon, polyurethane foam, insulation, and adhesive resins

Natural sources	• Seeds and fruit pits of *Prunus* species (eg, apple seeds and cherry and apricot pits)
Environmental sources	• Smoke inhalation in closed-space fires
Iatrogenic sources	• Sodium nitroprusside infusion

In the west, smoke inhaled from auxiliary flames is the most well-known reason for cyanide poisoning. Materials, such as, fleece, silk, and engineered polymers contain carbon and nitrogen and may deliver cyanide gas when presented to high temperatures amid thermal breakdown (Smith et al, 1994). In spite of the fact that carbon monoxide is generally connected with damage and mortality from smoke inhalation, examinations were done in which cyanide concentrations after smoke exposure were measured showing that cyanide harming can contribute freely and easily to injury and death. Cyanide is utilized as a part of industrial procedures that require electroplating and the cleaning of metals. Cyanide salts, for example, mercury cyanide, copper cyanide, gold cyanide, and silver cyanide deliver hydrogen cyanide gas when joined with acids, making the door open for accidents or intentional unsafe exposures. Cyanide is likewise found in bug sprays and pesticides used for some mass fumigations.

Iatrogenic sources of cyanide comes from the use of intravenous antihypertensive sodium nitroprusside. Nitroprusside can be cyanogenic; it is 44% cyanide by molar weight. Cyanide is discharged from the nitroprusside atom nonenzymatically. In the liver, the compound rhodanese at this point catalyzes the change of cyanide to thiocyanate, which is regularly discharged through the kidneys. Harming might be because of a misbalance in cyanide digestion or to a buildup of thiocyanate within the dosing period of a few days or more. Especially in patients with weaker renal capacity, cyanide harming may happen in light of the fact that the patients cannot discharge thiocyanate at a sufficient rate. Careful screening of renal capacity may help to prevent the patients who require sodium nitroprusside mixtures from harm. Serial observing can uncover rises in the serum level of cyan hemoglobin or cyanmethemoglobin. Levels more prominent than 10 mg/dL affirm thiocyanate harming and are a sign to stop treatment. Nitriles are a type of cyanide found in solvents and glue removers (Schepp et al, 2006).

Acetonitrile and propionitrile are the most regularly used nitriles. Converted to cyanide in the liver, acetonitrile is the dynamic ingredient in synthetic nail removers and has been connected to instances of cyanide harming. Despite the fact that it is not a regular reason for intoxication, natural sources can deliver cyanide intoxication when taken in substantial amounts or when they are given as supplement meds, for example, Laetrile. Cyanide happens normally in amygdalin, a cyanogenicglucoside. Amygdalin happens in very small amounts in the seeds and organic product pits (e.g., apple seeds, cherry pits, severe almonds, and apricot pits) of *Prunus* species.

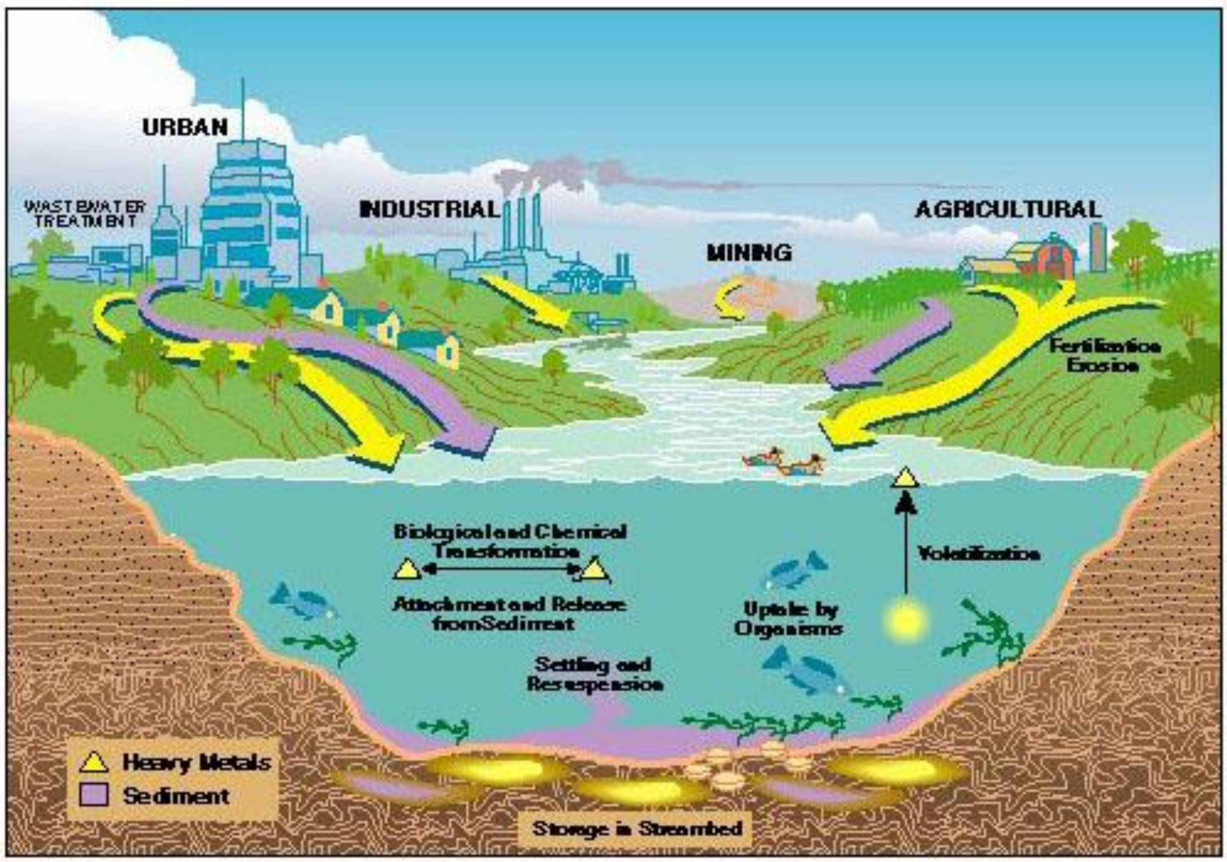

Figure 1.1 Sources of cyanide and distribution in the environment

1.3 Pathophysiology:

Cyanide is very deadly because of the fact that it diffuses into tissues and ties to target destinations in seconds. Intravenous and breathed in exposures cause more quicker onset of signs and symptoms than does oral ingestion because the initial 2 give quick dispersion and direct conveyance to target organs through the circulatory system. Oral or transdermal ingestion may deliver a deferral in signs and indications as focuses increment in the circulatory system. The essential system of cyanide discharge is development of thiocyanate inside the liver. Rhodanese catalyzes the transformation of cyanide to thiocyanate, and thiocyanate is then discharged by means of the kidneys. This system is overpowered by high dosages of cyanide in injured patients or in patients with degenerated kidney function (Barillo et al, 2009). The poisonous quality of cyanide is to a great extent ascribed to the suspension of oxygen consuming cell digestion. Cyanide makes intracellular hypoxia by reversibly restricting the cytochrome oxidase a3 inside the mitochondria. Cytochrome oxidase a3 is vital for the breakdown of oxygen to water in the fourth complex of oxidative phosphorylation. Attachment of cyanide to the ferric particle in cytochrome oxidase a3 restrains the terminal enzyme in the respiratory chain and inhibits electron transport and oxidative phosphorylation. This descending cascade is lethal if not turned back. Oxidative phosphorylation is required for the synthesis of adenosine triphosphate (ATP) and the continuation of cell respiration.

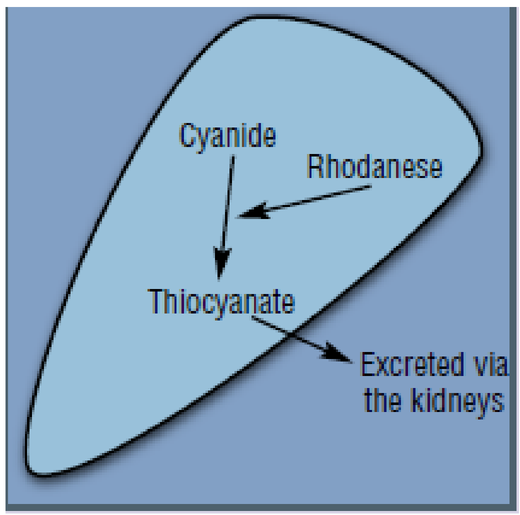

Figure 1.2 Metabolism of cyanide in the liver

As provisions of ATP end up noticeably exhausted, mitochondria can't concentrate or utilize the oxygen they are presented to. Therefore, metabolism moves to glycolysis by anaerobic metabolism, an ineffective method for energy, and delivers lactate. Generation of lactate brings about a high anion-gap metabolic acidosis. Poor oxygen extraction combined with suspension of vigorous cell respiration likewise prompts a buildup of oxygen in the venous supply (Hamel et al, 2011). In this circumstance, the issue isn't availability of oxygen rather the extraction and use of oxygen at the cellular level. The extra oxygenation of venous blood likewise confirms elevated venous level oxygen showed by blood gas examination and a diminished arteriovenous oxygen immersion contrast (<10 mm Hg). Some cyanide additionally ties to the ferric type of hemoglobin (a transient physiological type of met hemoglobin), which represents regularly 1% to 2% of all hemoglobin. Binding of cyanide to the ferric shape makes this sort of hemoglobin unequipped for transporting oxygen.

1.4 Clinical manifestation

The toxic effects of moderate damage include headache, nausea, lingering metallic taste in the tongue, restlessness, dazedness, fatigue, anxiety, mucous film bothering the upper air tract and hyperpnoea. Later frank dyspnoea, bradycardia, hypotension, arrhythmias develop overtime. In severe cases, dynamic extreme lethargies, shakings and cardiovascular collapsing with shock and respiratory edema can occur, with a deadly result. The clinical indications of cyanide toxicity are to a great extent a reflection of intracellular hypoxia.

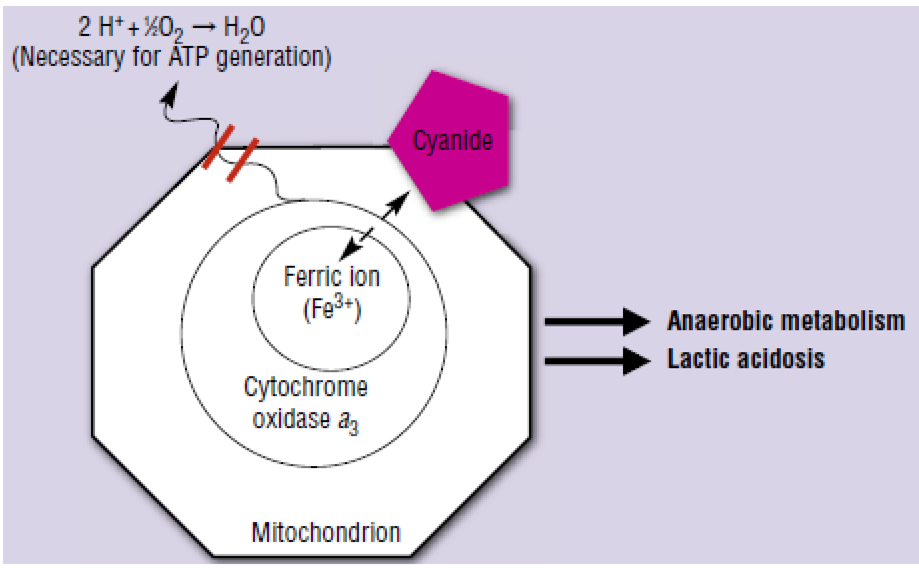

Figure 1.3 Effect of cyanide on cellular respiration

The beginning of signs and symptoms is typically under 1minute after breathing it in and within a couple of minutes after ingestion. Early neurological appearances include anxiety, cerebral pain, and giddiness. Patients may be not be able to focus their eyes, and mydriasis may develop as a result of hypoxia. As hypoxia progresses, patients may experience progressively decreased levels of consciousness, seizures, and trance state (Beasley and Glass et al, 1998). In intense cyanide toxicity, the skin may have a typical or a slightly ashen appearance not withstanding tissue hypoxia, and blood vessel oxygen saturation may additionally be within limits. Early respiratory signs of cyanide toxicity include transient fast and deep respirations. This respiratory alteration reflects stimulation of peripheral and focal chemoreceptors within the cerebrum stem in an attempt to counter tissue hypoxia.

System	Manifestations
Central nervous	Early (due to hypoxia) Anxiety Headache Giddiness Dizziness Confusion Mydriasis Bright retinal veins (elevated venous Po_2) Late Decreased consciousness Seizures Paralysis Coma
Respiratory	Early Hyperventilation and tachypnea (due to hypoxic stimulation of peripheral and central chemoreceptors) Late Absence of cyanosis (caused by an increase in oxygen content in venous blood) Hypoventilation Apnea (cells cannot take up oxygen)
Cardiovascular	Early Tachycardia Late Hypotension Supraventricular tachycardia Atrioventricular blocks Ventricular fibrillation Asystole

Figure 1.4 Effect of cyanide poisoning on different body systems

Cyanide has a significant hypoxic effect on the cardiovascular system. Patients may at first have palpitations, diaphoresis, tipsiness, or flushing. They may have an initial increase in heart yield and blood weight related with catecholamine discharge. Vasodilatation, hypotension, and a lessening in the inotropic capacity of the heart continue, with shunting of blood to the brain and heart. Cyanide discourages the sinoatrial hub, causes proneness to arrhythmias, and reduces the force of constriction of the heart. As toxicity increases, patients 'hemodynamic status may become imbalanced, with ventricular arrhythmias, bradycardia, heart blockage, cardiac arrest, and death. Serum concentration of cyanide greater than 0.5 mg/L are usually related with intense cyanide poisoning. Unfortunately this conclusion is not helpful in the underlying diagnosis and management of intense poisoning because of cyanide's fast action and lethality. Furthermore, measurement of serum cyanide levels may require several days, contingent upon the laboratoryfacility (Hamel, 2011). Serum cyanide concentrations also don't correlate with particular degrees of severity.

1.5 Management:

To start off managing patients with intense cyanide harming requires quick calculation and identification of the most likely route of contact to determine appropriate cleansing. Patients with suspected toxicity should first experience disinfecting by being cleared from the suspected zone and having their clothes removed. For patients with oral ingestion (Hall et al, 2007) who have regurgitated or spilled fluid on their skin or apparel, must be taken into account by medicinal services suppliers to evade auxiliary sullying. Suppliers should utilize individual defensive gear per the doctor's facility standard. During cleaning, the detoxification measurements may incorporate utilizing face veils, eye shields, and two fold gloving, with substitution of regular surgical gloves with butyl elastic gloves, which have a leap forward time of 1 to 4 hours. Emesis ought not to be initiated in patients with suspected ingestion. Activated charcoal might be given if the patient is ready, the time is within 1 hour of the speculated oral ingestion, and it isn't generally contraindicated. Despite the fact that it may not be viable in countering intense cyanide harming in view of the high strength of cyanide, the quick beginning of intoxication, and the little size of cyanide atoms, enacted charcoal might be helpful in patients who may have ingested another toxic substance notwithstanding cyanide. Because cyanide causes a lessening in oxygen usage, the organization of 100% oxygen by nonrebreather cover or endotracheal tube is shown in intense poisoning (Beasley and Glass et al, 1998). Although 100% oxygen won't right the issue, it might upgrade the viability of counteracting treatment by contending with cyanide for the cytochrome oxidase restricting sites. After cleaning and life-support measures are begun, the way to treat of cyanide toxicity is early administration of an antidote. The choice to manage the remedy should be made specifically, without full information of the patient's basic wellbeing status or confusing components (Hamel, 2011) Extra strong care incorporates controlling seizures with anticonvulsants, heart checking to assess and treat dysrhythmias and conduction imperfections, and pulse bolster with liquids and vasopressors. Care ought to be taken while managing intravenous liquids, in light of the fact that noncardiogenic pneumonic edema can be developed in patients with cyanide intoxication.

Hyperbaric oxygen may have a part in treatment, yet its utilization stays disputable and isn't standard practice. Routine research center examinations incorporate blood vessel blood gas investigation, estimation of serum lactate levels, and an entire platelet tally, estimation of serum glucose and electrolyte levels, and assurance of the serum cyanide level for affirmation. Normal research facility discoveries in cyanide harming incorporate metabolic acidosis, plasma lactate level more noteworthy than 8 mmol/L, and lessened arteriovenous oxygen immersion contrast (<10 mm Hg).

1.6 Treatment or antidotes:

Cyanide antidotes have been classified into three main groups according to their primary mechanism of action: sulphur detoxification, methaemoglobin formation and direct combination (Beasley and Glass,1998).

1.6.1 Sulphur detoxification

The most frequent used cyanide detoxifying system includes the expansion of a sulfur iota to shape the significantly less poisonous thiocyanate particle. The two largest chemicals in this procedure are mitochondrial rhodanese (thiosulphate-cyanide sulfur transferase) and B-mercaptopyruvate sulfur transferase. Different engineered combinations have been utilized as sources of extra sulfur to encourage this characteristic procedure. The most utilized has been sodium thiosulphate, in spite of the fact that this does not promptly enter the mitochondrial film inside which the rhodanese framework operates and is subsequently not perfect from a hypothetical premise. A novel antitoxin approach in individual consideration has been to administer exogenous rhodanese and a sulfur-giving compound, so that the whole reaction can happen promptly inside the blood, excluding the requirement for thiosulphate access into the mitochondria. However this has not advanced past the test arrange. So also the utilization of B-mercaptopyruvates or comparative sulfur givers, along with sulfur transferase chemical frameworks which are not intra-mitochondrial, has not advanced to the clinical stage.

1.6.2 Methaemoglobin formation

Different methaemoglobin formers have been tried as cures since it was watched that cyanide cooperates with met-Hb. In the transformation of oxy-Hb to met-Hb, the iron particles in the haem bunches are oxidized from the ferrous (2 +) to the ferric (3 +) state and it is the high partiality amongst cyanide and iron in the trivalent ferric state that is misused. Methaemoglobin development gives a huge circulating source of ferric particle to check the basic cyanide attachment to the ferric particle of cytochrome oxidase a3. While the coupling affinity of cyanide to metHb is not as much as that to cytochrome oxidase, the generation of a lot of the optional substrate can balance this circumstance to some degree, with a huge portion of cyanide binding to shape cyanmethemoglobin. This thus gradually discharges cyanide which diffuses out of the red cells in a progressive way creating plasma levels that can be promptly adapted by hepatic rhodanese and other sulfur detoxification protein frameworks. It has been standard to give exogenous sources of sulfur to encourage the procedure and this structures the premise of the established regimen upheld by Chen and Rose and others, of intravenous sodium nitrite and sodium thiosulphate. Methaemoglobin-producing chemicals have been separated into three gatherings: straightforwardly and by implication acting intensifies (the last requiring metabolic enactment), and those requiring the nearness of oxygen." While the nitrites are immediate acting, sodium nitrite is a moderately ease back metHb previous in respect to 4-dimethylaminophenol (DMAP). It is to a great extent thus that it has been superseded in Germany and different nations by DMAP (which falls into the third gathering). However there is prove that the impact of nitrites is just in part identified with met-Hb. In this way there is great confirmation for some restorative impact before any huge metHb development could have happened, and for sure in one test consider, when such arrangement was forestalled by methylene blue, sodium nitrite still presented insurance. Further, the impacts of nitrites on circulatory haemodynamics may offer a clarification. With cyanide, impacts on the cardiovascular framework can incorporate fundamental hypotension in relationship with a sharp increment in focal venous weight, while, following amyl nitrite treatment in trial thinks about, the raised CVP turned around quickly alongside change in blood vessel weight. This has been ascribed to the more noteworthy vasodilating impact of nitrites on the venous side than on the arteriolar protection vessels.

Medication	Dosing	Mechanism of action
Amyl nitrite	Crushed 0.3-mL ampule inhaled for 15 seconds; may repeat 3-5 minutes until intravenous access established Amyl nitrite should be discontinued once intravenous access is obtained and sodium nitrite infusion is started	Induces methemoglobinemia via oxidation to bind cyanide
Sodium nitrite	300 mg (10 mL in a 3% solution) or 10 mg/kg given intravenously for 3-5 minutes (a rate of 2.5-5 mL/min) in adults 6-8 mL/m^2, or 0.2 mL/kg in children, not to exceed 10 mL	Induces methemoglobinemia via oxidation to bind cyanide
Sodium thiosulfate	1 ampule, or 12.5 g in 50 mL, given intravenously for 30 minutes in adults The dosage for children is 7 g/m^2, not to exceed 12.5 g	Combines with unbound cyanide to form renally excreted thiocyanate
	Hydroxocobalamin	
Hydroxocobalamin	5 g for adults, administered intravenously for 15 minutes, repeat a half dose if needed; 70 mg/kg in children	Combines with unbound cyanide to form cyanocobalamin

Figure 1.5 Antidotes to cyanide poisoning (Hamel, 2011)

1.6.3 Direct combination

Cobalt mixes have gotten by a wide margin the best consideration as immediate combiners with cyanide, with impacts noted before the turn of the century and since affirmed by a few specialists. Critical lethality was seen with different cobalt salts, nonetheless, so mixes, for example, dicobalt edetate (cobalt EDTA) containing cobalt in a chelated shape, were likewise examined in the expectation of their being less dangerous. Evans analyzed a cobalt salt (the acetic acid derivation), di cobalt edetate, hydroxocobalamin and cobinamide, to a great extent in mice and rabbits. He reasoned that 1 mole of cobalt as a salt could consolidate with 6 moles of cyanide to frame a generally non-harmful anion, while di cobalt edetate joins at a molar proportion of 2 as it were. One along these lines may expect that equimolar dosages of the edetate ought to be less lethal (and effectual) than cobalt salts. However this inquiry does not seem, by all accounts, to be settled totally. Absolutely poisonous quality with Kelocyanor (the business type of di cobalt edetate) can happen; this might be connected partially to the way that this planning contains some extra free cobalt. As respects viability, Paulet asserted that di cobalt edetate was more powerful in canines than different cobalt salts, and indeed,more viable than sodium nitrite either alone or in mix with thiosulphate. Hydroxocobalamin (Vitamin B12a) was later researched as a conceivably less poisonous wellspring of cobalt. It ties cyanide emphatically to shape cyanocobalamin or Vitamin B12. In certain individuals it was observed to be a quickly acting antitoxin and clinical investigations have proposed couple of poisonous impacts. The antitoxin impact is improved by thiosulphate.

1.7 Advantages and disadvantages of the type of treatment:

Assessment and examination of antitoxins, with respect to relative viability and lethality, isn't direct.

Results from creature ponders must be deciphered circumspectly, offering thought to conceivable between species differencesplus the specific course and timing of remedy organization with respect to that of the poison. Prophylactic or contemporaneous utilize gives no thought of the time after introduction inside which treatment can at present be viably started. Then again elucidation of human case reports can likewise be troublesome in view of vulnerabilities over the dosage ingested or the introduction levels included, and consequently the presumable clinical course without counteractant treatment. Along these lines it has been pointed out that in the survey by Chen and Rose of 48 cases proposing a high adequacy of the 'established' treatment mix, in not very many were blood cyanide levels or different records of seriousness reported. Indeed, even where such files are accessible, it is hard to recognize the parts played by various components of the treatment regimen, and to characterize the commitment of a particular counteractant. (In fact, there is great confirmation that cures are not generally basic for a tasteful result even within the sight of serious harming).

By and by endeavors have been made at correlation inside the breaking points of the information accessible. Paulet found that Kelocyanor was more successful than sodium nitrite alone or in mix with thiosulphate. This isn't astounding given its moderately fast response with cyanide contrasted and the slower, circuitous impact of metHb development by nitrites, despite the fact that the last may act in different routes as well. However a few investigations have proposed that the quicker metHb previous, DMAP, could be more compelling than Kelocyanor. A firm conclusion in regards to relative viability seems hard to make, unquestionably from the human information alone. While Kelocyanor might be somewhat more successful than the nitrites, it might be less so than DMAP, and the adequacy of the considerable number of remedys is upgraded by thiosulphate. Halfway because of these vulnerabilities, poisonous quality contemplations are imperative in any assessment. The real worry with nitrites and DMAP is over the top metHb creation. This is a specific hazard in youthful children, with genuine complexities and passing being portrayed particularly in those more defenseless because of metHb reductase deficiency. MetHb levels over around 40% stance huge hazard. It is built up that cyanide poisonous quality, and also carbon monoxide (and smoke particulates) can be a hazard for flame victims and the likelihood of consolidated lethality or even collaboration ought not to be ignored.

Antidote	Adverse effects	Other considerations
Cyanide antidote kit	Potent vasodilatation from the nitrites may lead to hypotension Methemoglobinemia may be harmful or even lethal in patients who already have a deficiency of oxygen-rich blood, such as those exposed to carbon monoxide	Monitoring of methemoglobin levels is indicated and should not exceed 20% Contraindicated in smoke-inhalation patients Is not considered safe in pregnant patients
Hydroxocobalamin	May cause transient hypertension Most common adverse effects include reddening of the skin and urine	Is safe for smoke-inhalation patients May be used in pregnant patients May interfere with colorimetric tests because of its red color Effect on blood pressure may be beneficial in patients in shock

Figure 1.6 Side effects and other considerations of Antidotes (Hamel, 2011)

It is best, in any case, that any cyanide part ought not be treated with metHb formers, as huge carboxyHb may as of now be available, decreasing oxyHb levels and presenting expanded affectability to such agents. Further, a level of 'gauge' methaemoglobinaemia has been portrayed in smoke inward breath victims, fortifying the contention for different sorts of antitoxins for any cyanide segment in this circumstance. A further trouble is that while the level of methaemoglobin can be measured, the test does not in truth identify cyanmethaemoglobin and consequently does not give an exact manual for the measure of oxyhaemoglobin. Hypotension has additionally been refered to as a peril with nitrites, in spite of the fact that the cardiovascular impacts of nitrites can be beneficial and the danger relates more to unreasonable speed of administration. DMAP does not have the detriment of nitrites in representing a danger of hypotension. In any case it additionally does not share their gainful vasoactive properties, and given its more quick creation of metHb, may represent a more serious hazard for those particularly vulnerable to this effect which can be capricious in its degree. Haemolysis is an uncommon entanglement from nitrites and is additionally a hazard with DMAP, patients with glucose-6-phosphatedehydrogenase insufficiency being most susceptible. Toxicity is a noteworthy worry with Kelocyanor.

Antagonistic impacts incorporate conceivable anaphylactic responses which may show as urticaria, angioedema influencing the face and neck and furthermore every so often the larynx, dyspnoea and hypotension. Heart arrythmias and shakings have likewise been portrayed. The cobalt and cyanide communication includes common inactivation with the goal that the blend is less dangerous than either all alone. Accordingly cobalt poisonous quality as such ought to be substantially less of a hazard in situations where cyanide harming really exists. This has prompted proposals that Kelocyanor should just be utilized as a part of settled cases and not in obscure situations where introduction appears to be only a possibility. This requires clinical experience and strict criteria for the determination, as on edge patients associated with 'alarms' over conceivable exposures may show signs and side effects looking like gentle or early harming. Organization of Kelocyanor in such cases would not be justified and will probably bring about harmfulness. While decision making ability has for the most part brought about couple of unfavorable impacts in modern settings, unseemly use with unfriendly outcomes remains a possibility.

Sodium thiosulphate	50 ml of 25% solution (12.5 g) IV over 10 min
Sodium nitrite	10 ml of 3% solution (300 mg) IV over 5–20 min
4-DMAP	5 ml of 5% solution (250 mg) IV over 1 min
Dicobalt edetate	20 ml of 1.5% solution (300 mg) IV over 1 min
Hydroxocobalamin	10 ml of 40% solution (4 g) IV over 20 min

Figure 1.7 Recommended Cyanide antidote regimen (Beasley and Glass, 1998)

Besides, poisonous responses have been portrayed even in instances of unequivocal cyanide poisoning. The lethality is impressively decreased by co-organization of glucose (component questionable), which is in this way joined into the detailing. However the proposal not to use in dicey or mellow cases still stands. The moderately low danger of hydroxocobalamin joined with its fast activity are significant focal points of its utilization. However a pragmatic burden is that huge volumes of the business readiness are required to convey an adequate measurement, because of its high atomic weight in addition to the way that it can just join with cyanide on a balanced molar premise. In this way detoxification of 1 mmol cyanide (or 65 mg KCN) requires 1406 mg hydroxocobalamin, while in many nations it is just accessible in plans of 1-2 mg. In different nations it is accessible as a reconstitutable powder yet at the same time requires substantial volumes of arrangement best given as an IV imbuement, making its utilization outside a healing center condition rather unrealistic. It has been utilized primarily in France, regularly in blend with thiosulphate, for a few years. While clinical experience somewhere else has been constrained, this mix is increasing expanding support, chiefly due to its evident lower lethality and less in danger circumstances than with the other real choices. The most widely recognized unfavorable impact is a safe orange-red staining of the skin, mucous films and pee. However a few issues stay to be tended to, for example, its relative cost and evident poisonous quality in creature studies. The discoveries from cyanide remedy examination practices are ostensibly obscure as opposed to obvious, and this gives off an impression of being reflected in the proposals of the IPCS/CEC Committee set up for their assessment. In this manner the two metHb producing mixes talked about above are exhibited as choices, similar to the two cobalt mixes. This might be somewhat because of functional contemplations, for example, the fluctuated clinical encounters and authorizing plans in various nations. The design of the review in this production however may display some danger of error.

1.8 Factors in the choice of antidote

The IPCS/CEC Committee recognized a few elements which should impact the decision of counteractant (assuming any) to use in cyanide harming. These include: (1) the nature of the cyanide compound and the introduction conditions; (2) the seriousness of harming; (3) the nearness of certain hazard factors for remedy poisonous quality; (4) the quantity of patients included and (5) vicinity to healing center offices This suggests there is no single best antitoxin for all circumstances. Hence nitrites or other metHb formers can't be prescribed for flame casualties, youthful kids or those with certain catalyst (e.g., G6PD) insufficiencies which increment defenselessness (Beasley and Glass,1998). .

1.8.1 Mild poisoning

Where side effects recommend mellow harming, rest and oxygen treatment might be all that is required. Any decay is a sign for amyl nitrite treatment (0.2-0.4 ml through Ambu pack) and course of action for exchange to healing center. Side effects might be to some degree deferred with a few mixes (e.g., acetonitrile) which just discharge cyanide on digestion and judgment is required on if and when to exchange. While amyl nitrite has been found (in any event in inward breath and self-organization) to create just extremely unassuming metHb levels (up to 7%) which are lacking to tie a conceivably deadly measurements of cyanide, there is expanding proof that the cardiovascular impacts of nitrites are their most vital instrument of activity.

1.8.2 Moderate poisoning

For more direct harming where side effects may incorporate brief times of obviousness, writhings or cyanosis, intravenous antitoxins are likewise shown. Plainly these are most effortlessly regulated inside a healing facility setting, in a perfect world an emergency unit, general administration will be best. Sodium thiosulphate might be the main decision, especially if the analysis is questionable.

1.8.3 Extreme poisoning

In serious harming with profound trance state, enlarged non-responding students and declining cardiorespiratory capacity, an extra intravenous remedy ought to be regulated. Methaemoglobin formers can be risky in a few conditions, and kelocyanor can be a hazard especially when cyanide harming is an off base conclusion. From an entirely hazard advantage perspective, hydroxocobalamin is ostensibly the best option. However because of its relative cost and some functional challenges with organization, it is plausible that nitrites and kelocyanor will hold a part, especially for doctors comfortable with them. Rehash dosing might be demonstrated on account of a poor reaction. Suggestions are a similar dosage for thiosulphate or Kelocyanor, or a large portion of the underlying measurement of sodium nitrite after a 30 min interim. In any case it is emphatically encouraged to audit the conclusion and screen for lethality before rehash dosing with Kelocyanor or sodium nitrite.

1.9 Supportive treatment

What has developed is the significance of oxygen treatment and the requirement for progressing clinical and biochemical checking. There is presently test prove that oxygen has particular counteractant activity. It can quicken the reactivation of cytochrome oxidase and may have different methods of activity. Simulated ventilation with 100% oxygen is suggested, however for no longer than 12-24 hours at this fixation. Observing of blood vessel blood gasses, liquid and electrolyte adjust, level of awareness and circulatory status including CVP estimations are basic notwithstanding concentrated help of respiratory capacity. Blood cyanide estimations are helpful as an additional manual for administration (Hall et al, 2007). However the considerable larger part of cyanide in the circulation system dwells in the red cells (even without metHb arrangement) so the test may not precisely reflect plasma levels of free cyanide which presumably associates better with side effects. In any case the IPCS/CEC survey recommends that gentle harming is frequently connected with blood fixations beneath 2 mg/1 while the most extreme cases for the most part have levels over 3 mg/1 and such levels might be a helpful subordinate in checking the clinical course.

Chapter 2: Exposure of cyanide

2.1 Forms of cyanide pollutant:

2.1.1. Hydrogen Cyanide

Hydrogen cyanide (CAS 74-90-8), HCN, is a dreary, toxic fluid with the trademark scent of intense almonds. It is a low consistency fluid at 25°C and has a breaking point of 25.70°C. Hydrogen cyanide is miscible in all segments in water and liquor, and is dissolvable in ether. Hydrogen cyanide polymerizes precipitously when not totally unadulterated or balanced out. The stabilizer utilized is sulfur dioxide and sulfuric corrosive. Hydrogen cyanide is essentially utilized as a fundamental building hinder for other substance items, for example, adiponitrile, methyl methacrylate, cyanuric chloride, sodium cyanide, potassium cyanide, and an assortment of chelating agents. Hydrogen cyanide is an exceptionally powerless corrosive, having an ionization steady of an indistinguishable greatness from normal amino acids. As the nitrile of formic corrosive, HCN experiences numerous normal nitrile responses. For instance, HCN can be hydrolyzed to formic corrosive by watery sulfuric corrosive, changed over to phenylformamidine with aniline and hydrogen chloride, or hydrogenated to methylamine. It likewise responds with the carbonyl gathering of aldehydes and ketones to frame cyanohydrins. The most vital employments of this kind of response are in the fabricate of CH3)2CO cyanohydrin (a middle of the road in the generation of methyl methacrylate) and in the creation of adiponitrile from HCN and butadiene (Mudder and Botz, 2004).

2.1.2 Sodium Cyanide

Sodium cyanide (CAS 143-33-9), NaCN, is a white, cubic crystalline strong and is exceptionally dissolvable in fluid smelling salts. It is scentless when dry yet discharges a smell of intense almonds when sodden. Today, NaCN is delivered by the balance or wet process, in which fluid HCN and sodium hydroxide arrangement respond and water is vanished.

2.1.3 Potassium Cyanide

Potassium cyanide (CAS 151-50-8), KCN, is a white crystalline strong that breaks down to fluid by retaining dampness from the air. Business KCN is right now delivered by the balance or wet process, which responds as fluid arrangement of potassium hydroxide with hydrogen cyanide to create KCN at 99 percent immaculateness. Potassium cyanide of 99.5+ percent virtue can be set up by utilizing great HCN and potassium hydroxide (KOH). Potassium cyanide does not shape a dihydrate.

<u>2.1.4 Other Cyanide Compounds</u>

Other cyanide mixes incorporate lithium cyanide, rubidium cyanide, cesium cyanide, ammonium cyanide, strontium cyanide, magnesium cyanide, barium cyanide, and calcium cyanide. Of these mixes, just calcium cyanide is monetarily essential, despite the fact that fabricate has been enormously lessened lately.

2.2 WHO Guideline for cyanide limit in water

Cyanide may bring down vitamin B12 levels and subsequently worsen vitamin B12 lacking. It has been connected to a lingering frequency of goiter (cretinism) in Zaire through consequences for iodine take-up by the thyroid. Those with lack of nutrition or intrinsic metabolic troubles are especially defenseless. Unending consequences for the thyroid and especially on the anxious framework were seen in a few populaces as an outcome of the utilization of deficiently handled cassava containing large amounts of cyanide. This issue appears to have diminished altogether in the West African populaces in which it was broadly detailed following an adjustment in handling techniques and a general change in dietary status.

<u>Water</u>

Cyanides are usually found in drinking-water, mainly as a result of industrial contamination.

<u>Food</u>

Dietary presentation to cyanide is significantly high in third world nations than in developed ones. For a bunch of 73 subjects in Liberia eating cassava, the average ingestion of cyanide particle was figured to be 0.61 mg/kg of body weight. Albeit information is little, from which to ascertain the normal day by day allow in created nations, it is probably not going to be this high.

There are very little number of toxicological investigations reasonable for use in determining a definite value. There is, some sign in the reviews that pigs might be more prone than rats. Just a single report is accessible in which a definite impact level was seen, at 1.2 mg/kg of body weight every day, in pigs uncovered for a half year. The impacts seen were on behavioral changes and serum biochemistry. Utilizing the LOAEL from this investigation and applying a vulnerability factor of 100 to reflect inter and interspecies variety (no extra factor for a LOAEL was viewed as fundamental in view of questions over the natural importance of the watched changes), a TDI of 12 μg/kg of body weight was ascertained. A distribution of 20% of the TDI to drinking-water is made in light of the fact that exposure to cyanide from different sources is quite low and that exposure from water is just irregular. This outcomes in a rule estimation of 0.07 mg/liter (adjusted figure), which is thought to be defensive for both short and long-term presentation.

According to WHO guidelines the cyanide content in water should not exceed 0.6 mg/L and any value less than or equal to this is permissible. As mentioned by the USEPA guidelines cyanide in water should not exceed 0.2 mg/L and any value less than this is considered safe for drinking.

Chapter 3: Use of cyanide in different sectors

Production of acrylonitrile:

Cyanide is used in the production of acrylonitrile. It is an intermediate step in the production of acrylic fibers, rubber and plastic. Overall the plastic industry has a massive and regular use for cyanide in a named process called Fumigation. Combustion of plastics or intermediate forms of this results in the production of toxic forms of cyanide gases which can cause mass poisoning especially amongst those nearest to the production such as the working staff.

Iron and steel industries:

Cyanide is also diversely and independently used in the case hardening of iron and steel in the iron mills and steel producing factories. Used during metallurgy of electroplating of metals to coat and give fine finish and cleaning metals to give a smoother texture, cyanide has a significant commercial use in metal industries.

Gold mining:

Mining has a huge role for cyanide as well. Gold and silver ores are mined with the help of cyanide. The extraction process is catalyzed and also gives higher yields with its use. Since these are expensive and precious metals extraction are expected to have a higher yield value to make the process feasible and guarantee more metals extraction from the ore as much as possible.

Paper industry:

Paper industry uses cyanide as well. Sodium cyanide is used in the manufacturing procedure of paper. To modify starch with different chemicals sodium cyanide is used as a part of hydrolysis. Even though used in small amounts, regular use can cause gradual build up and also exposes the workers to forms of toxic cyanide.

Textile Industries:

Textile industries have a notable use for cyanide as well. Colors and dyes used in textile industries contain amounts of cyanide. Acute cyanide poisoning is common in jewelry and textile industrial workers. The wastes are dumped or filled into nearby water bodies in countries like Bangladesh where the locals use the water body as a general source of water.

Photograph Printing:

Cyanide is used in developing photographs. The chemicals used to develop photographs from negatives use significant amount of cyanide that is not negligible. Manhandling or misuse of these chemicals can lead to potential acute poisoning of the person developing the photographs.

Pesticides:

Cyanide is used vastly as an important ingredient in pesticides and insecticides and bug sprays. Easy option for quick extermination, in some places in the world especially in third world countries, locally produced insecticides and bug spray contain free cyanide without any control value. The factories where these are produced as also at a huge risk of contaminating the area nearby if not already done. When used as a pesticides sprays maybe be inhaled by the users as well giving them acute cyanide poisoning on the spot. Pesticides used on agriculture can also leech into the ground contaminating the water supply of deep tube wells and submersibles in third world Asian countries.

Furniture at home:

Acetonitrile based products contain cyanide and its combustion has the potential to create acute cyanide poisoning. Long-term use of furniture that uses nylon and rayon and other artificial or synthetic polymers plastic based products also in time give off cyanide gas. But the amounts are so negligible and the constant air circulation probably has no effect on the residents. It would be a cause of concern if the house was closed down or uninhabited for a long time with the furniture intact. A local fire in the house containing plastic furniture or acetonitrile products has the potential to cause massive damage by cyanide toxicity to the residents or workers of the place.

Polythene burning:

Burning plastic bags especially the shopping bags used in the Indian subcontinent as a popular carrying bag give off cyanide fumes along with other toxic materials that can cause permanent or long term CNS or cardiovascular impairment. It was a regular ritual to burn plastic bags in this region as people were unaware of its toxicity. It has however decreased drastically after several awareness campaigns about its toxic potential and damage to the society. Biodegradable plastic bags however are a greener alternative and do not contain cyanide or combust to give cyanide.

Pharmaceutical industries:

In the pharmaceutical industries reactions are done to form nitriles from organic halides. These section of reactions cause a production of cyanide which if not taken proper care of could cause acute cyanide poisoning to the worker carrying out the procedure. It is a wide range of reactions with a variety of substitutes but cyanide as a byproduct seems to be inevitable. This cyanide if not properly disposed of can create a mass poisoning if slowly contaminates or develops in the surrounding air or if leeches into the soil if proper waste management is not done.

Tannery:

The tanning industry is a widely popular and vast sector in the south Asian culture. The ingredients in the tanning procedure contains cyanide especially the dyes. The procedure itself uses chemicals that give off notably god amount of cyanide which if trapped inside the workplace could create cyanide poisoning for the workers either immediately or in a long term toxification process.

Printing press:

The newspaper or printing industry uses cheap dyes for cheap printing which contains cyanide. These cyanide can be exposed to the individual through improper handling of chemicals or not maintaining proper hygiene or workplace ethics. Maintaining gloved hands is a very effective way to stop ingestion of cyanide through the mouth or nose or eyes or any part of the body the bare hand touches. Open scratches are particularly susceptible to cyanide poisoning from these chemicals.

Agriculture

The agriculture industry uses a lot of pesticides and bug sprays mentioned above that contains cyanide and can leave traces or linger in the agricultural product. Proper cleaning procedures are necessary to make sure these open pesticides do not poison the farmers or the consumers or anyone in between that handles the products and is exposed to cyanide by inhalation or ingestion.

Chapter 4: Rationale

The following are my justification for choosing to work on this project:

1. **Cyanide is an extremely toxic gas:** cyanide gas is released by different industrial sources and it does not have a definite antidote.
2. **High prevalence of industries:** Bangladesh being a developing country has a rapidly increasing number of industries that use or release cyanide in one way or another.
3. **Industrial wastes are dumped into nearby water bodies:** these industrial wastes may include cyanide in one form or another and get accumulated in the water bodies, increasing in concentration every time.
4. **Water bodies are the main source of water:** Since a large amount of the population do not have proper sanitation, for slum dwellers, the natural water bodies in the city are the main source of usable water. Water can be a source of cyanide exposure to these people on a regular basis.
5. **Cyanide can leech into the soil:** When the wastes are dumped into the water bodies cyanide can leach into the nearby areas getting into tube well water supply or drinking water supply.
6. **WHO gave an approximate guideline value of 0.07mg of cyanide in per litre of water:** This is the safe limit for both short term and long term exposure of cyanide. I tested if the cyanide concentration in the water samples around Dhaka city had values within this limit, using colorimetric and titrimetric method.
7. **Antidotes for cyanide poisoning are limited:** Antidites for cyanide are effective only when administered within a short time of the event of poisoning. Hence a mass cyanide toxicity could result if cyanide contents exceed safety limits in drinking or usable water supply of the population.

Chapter 5: Methodology

The whole method is divided into five major parts:

1. Survey and sample collection
2. Preparation of reagents
3. Preparation of standard curve
4. Pretreatment and distillation of samples before analysis
5. Analysis using titration and colorimetric method

5.1 Survey and sample collection:

Specific locations were chosen within Dhaka district that contained a large water body which served as a reliable source of water on a daily basis. 8 areas were divided into 4 major sectors: Rural, Industrial, Commercial and Residential. Each classification has 2 areas within it. Each area has 3 types of water samples that were analyzed: Tap water, tube well water and water from the major water body of that area.

Table 5.1 Surveyed areas

Type of Area	Names of the locations
Rural	Rupganj
	Gazipur, Turag
Industrial	Shyampur, Kodomtoli
	Meghna bank, Sonargaon
Commercial	Tejgaon, hatirjheel
	Motijheel, Jatrabari
Residential	Banani
	Dhanmondi

Areas were classified based on the number of industries, offices and markets, types and class of residents, main purpose and availability of various commodities and its distance from the main metropolitan.

5.2 Preparation of reagents:

Since most of the reagents were not directly commercially available, they were made inside the laboratory by maintaining the proper EPA guidelines. All chemicals used were reagent grade pure. Water used as the solvent was distilled water unless mentioned otherwise in procedure.

5.2.1 For pretreatment and distillation:

Reagents were prepared in the laboratory which were not available directly. Water used was distilled water unless mentioned otherwise. The method of preparation is shown in Table 4.2 below.

Table 5.2: Reagents for pretreatment and distillation

	Reagents	Preparation
1	Calcium hypochlorite (0.35M)	Add 5g of calcium hypochlorite to 100ml water. Used lukewarm water for better solubility
2	Sodium hydroxide (1.25N)	50g of sodium hydroxide in 1 liter water
3	KI starch paper (commercially available)	
4	Sodium arsenite (0.1N)	3.2g sodium arsenite in 250ml water
5	Bismuth nitrate (0.062M)	30g bismuth nitrate in 100ml water. Followed by 250ml glacial acetic acid while stirring until dissolved. Dilute to 1 liter with water
6	Lead acetate paper (commercially available)	
7	Sulphamic acid (0.4N)	40g powder in 1 liter water
8	Sulfuric acid (18N)	500ml of concentrated sulfuric acid slowly added to 500ml water
9	Magnesium chloride (2.5M)	510g powder in 1 liter of water

5.2.2 For Titration:

The reagents prepared for titration analysis and its method is shown below in Table 4.3.

Table 5.3: Reagents for titration

	Reagents	Preparation
1	Rhodanine indicator	20mg of p-dimethylamino-benzal-rhodanine in 100 of acetone
2	Silver nitrate standard solution (0.0192N)	Crush about 5g of silver nitrate and dry up to a constant weight at 40 degrees Celsius. Weighed out exactly 3.2647g of the dried powder and dissolved in 1 liter of water

X

5.2.3 For Colorimetric (spectrophotometric) determination:

The reagents prepared for colorimetric (spectrophotometric) analysis and its method is shown below in Table 4.4.

Table 5.4: Reagents for colorimetric analysisX

	Reagents	Preparation
1	Sodium phosphate monobasic (1M)	138g in 1 liter water. Kept under refrigeration
2	Chloramine –T solution (0.44%)	Dissolved 1.0g of water soluble powder in 100ml water. Kept under refrigeration
3	Pyridine barbituric acid reagent	15g of barbituric acid taken in 250ml volumetric flask. Water added just enough to wet powder and wash the sides. 75ml of pyridine added and mixed. 15ml of concentrated hydrochloric acid added and mixed until cooled to room temperature. Dilute upto 250ml with water and mix until clear solution formed. Stored in cool and dark place.
4	KI starch paper (commercially available)	

5.3 Preparation of standard curve:

I have made a standard curve, according to the instructions given in Method 9014, to calculate the concentration of cyanide from the samples collected. The standard curve contained the following diluted concentrations made from the working standard stock solution of potassium cyanide prepared in the laboratory.

Calculations were done according to the following equation:

$$CN^{-}\ (\mu g/L) = \frac{A \times B \times C}{D \times E}$$

Where: A = µg/L CN− read from standard curve.
B = mL of sample after preparation of colorimetric analysis (100 mL recommended).
C = mL of sample after distillation (250 mL recommended).
D = mL of original sample for distillation (500 mL recommended).
E = mL used for colorimetric analysis (50 mL recommended

Table 5.5 Standard curve dilution values **X**mL of working standard solution (1mL=10µg CN-)	Concentration (µg CN-/L)	Final Concentration (µg CN-/L)	Absorbance
0	Blank	0	0
1	40	20	0.045
2	80	40	0.109
5	200	100	0.198
10	400	200	0.388
15	600	300	0.6
20	800	400	0.8

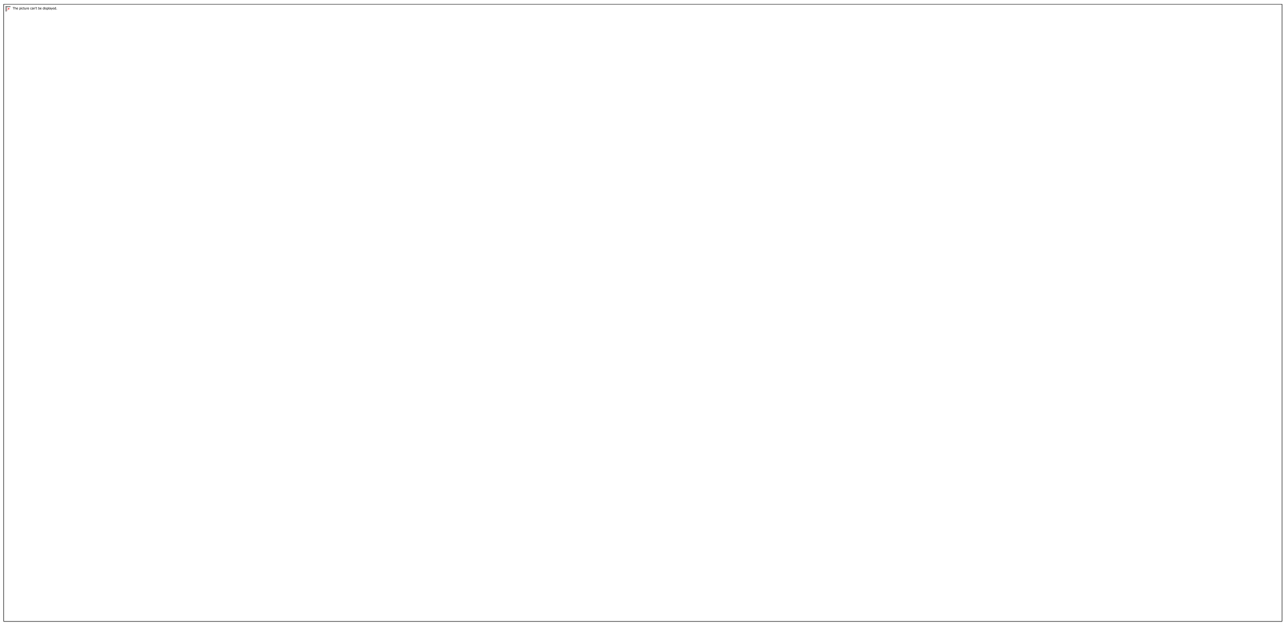

Figure 5.1 Standard curve prepared using Table 5.5

5.4 Setting apparatus:

Apparatus is set up as shown in figure. Every end is checked for gas leaks and made sure that air only flows in one direction into the gas scrubber. A glass rod was used for agitating and mixing the reagents added to sample solution. Vaccum was run throughout the procedure and when turned off, air inlet was covered with aluminium foil before turning off the vacuum and opened after the vacuum was started again. It was ensured that all air flowed into the gas scrubber solution.

5.5 Pretreatment:

1. Reaction is done only in amber light to not let potassium ferrocyanide decompose under fluorescent light or sunlight.
2. 500 mL sample was taken into the two mouth round bottom flask. Calcium hypochlorite solution was added drop by drop and checked for an excess chlorine with KI starch paper. pH was kept between 11 and 12 with 1.25N sodium hydroxide solution prepared beforehand.
3. And excess chlorine content was indicated by KI starch paper and this condition along with stirring was maintained for one hour to develop.

4. After one hour was complete 1 mL portions of sodium arsenite was added and checked with KI starch paper until it no longer turned blue. This ensured excess chlorine was eliminated. An excess of 5 mL sodium arsenite was added to make sure reducing agent was in excess.

5.6 Distillation:

1. Apparatus was kept intact as in the pretreatment phase and vacuum suction into gas scrub was kept at all times.
2. 50 mL of 0.062 bismuth nitrate solution, previously prepared, was added through the air inlet. This was used as a test to remove suspected interference from sulfides in the sample. Stirring was continued for 3-4 minutes and solution checked with lead acetate paper for sulphide presence. A grey black change would be a positive result for the presence of sulphide.
3. Since bismuth nitrate was added and to remove any other nitrate interfering compounds in the sample, 50 mL of 0.4N Sulphamic acid, previously prepared, was added into the sample solution through air inlet. Stirring was continued for 3-4 minutes. Care was taken to not add Sulphamic acid in excess to prevent method bias.
4. 50 mL of sulphuric acid was gradually added through air inlet and the inlet rinsed with distilled water. Sample solution was agitated for 3-4 minutes.
5. 20 mL of magnesium chloride was added through the air inlet and distilled water was used to rinse the tube opening. Mixture agitated for 3-4 minutes and heating mantle was turned on.
6. Solution was heated until boiling started and then refluxed for 1 hour without vacuum. Air inlet was kept close using aluminum foil. Heating was stopped and vacuum was turned on to get steady airflow into the gas scrubber for about 20-25 minutes. Vacuum was turned off when the boiling flask had cooled off a little. Gas scrubber was disconnected from the system.
7. The contents of the scrub was then used in titration and spectrophotometric methods.

5.7 Analysis:

5.7.1 Titration method for detection and analysis:

1. 50 ml portion of the gas scrubber solution was taken into a 250ml Erlenmeyer flask or conical flask.
2. Rhodanine indicator, previously prepared, was added 10-12 drops into the flask.
3. Titration was done using standardized 0.0192N silver nitrate, freshly prepared daily. Titration was carried out in gradual drops with constant stirring.
4. A distinct color change from straw yellow to brownish pink indicated the end point and titration was stopped. A blank with the same amount of sodium hydroxide and indicator was titrated the same way.

5.7.2 Spectrophotometric (colorimetric) determination:

1. Transferred 50 mL of scrubber solution into a 100 mL volumetric flask with a pipette.
2. 15 mL of 1M sodium phosphate, refrigerated then warmed to rtp, was added into the volumetric flask and mixed.
3. 2 mL of chloramine-T added to the solution and mixed well. After a minute solution was tested with KI starch paper for excess chlorine. Chloramine-T was added in 0.5 mL portions until KI starch paper indicated blue.
4. After 1-2 minutes 5 mL of pyridine barbituric acid, previously prepared, was added into the mixture and mixed.
5. Solution was diluted up to the 100 mL mark with distilled water and kept for 10 minutes for color to develop.
6. Absorbence was taken at 578 nm in a 1cm glass cuvette. Values were then compared accordingly with the standard curve prepared previously.

Chapter 6: Result and discussion

Samples were collected and analyzed within 24 hours of collection. Each area type consists of two areas of the same type and three types of water samples from each. The survey tables include additional information about the areas in general including how densely populated it is, the type or class of population and their access to sanitation, need of water from natural sources and the industries in the area.

6.1: Area type : Rural industrial

<u>6.1.1 Area 1: Rural Industrial Area Gazipur</u>

Table 6.1 Area survey for Rural Industrial Area Gazipur

Area survey form: 1	
Name of area	Turag Gazipur
Area size	12.17 km²
Part of Dhaka	North
Type of area	Rural and Industrial
Approximate Population	57 thousand
Type of dwellers	Villagers, Workers, Labors
Percentage living in household with tap water supply	Less than 5%
Main type of housing	Mostly huts or low tin shed buildings
Shop and restaurant density	10 or less
Number of factories	greater than 25
Type of factories	Garments, Brick mill, plastic and paint, Pharmaceuticals
Main water body	Turag River
Mostly used water source by percentage	Tap less than 5%
	Tubewell 20%
	River/Lake 75%
Exposure or main source of pollution	Brick mills furnace
	Plastic industry waste
	Garments waste

Table 6.2 Rural Industrial area Gazipur sample analysis results

Rural area Gazipur results		
Name of sample	Absorbance	Concentration of CN- (µg/L)
Turag river water	0.12	57.2
Tap water	0.063	28.3
Tube well water	0.009	0.97

Discussion:

Gazipur is mainly a rural location with recent developments of industries around the banks of the river Turag. The recent flocking of industries is due to the availability of abundant water supply from the river residents are mainly local villagers including middle to lower class workers of the industries. Houses are mainly huts or economical housing for workers which do not often include proper sanitation system. Hence the locals are dependent on the river or tube well water for day to day water supply. Although quite close, the water samples have not crossed the WHO limit (70 µg/L) for cyanide in water.

Turag river water: Even though the value is within limits, it is still dangerously close to the limit given by WHO. The use of the river as a water source and dumping ground for industries such as textiles, plastic, garments can be a probable reason for this outcome. Brick mills furnace burns to give off a significant amount of hydrogen cyanide which may have accumulated over time in the river waters.

Tap water: Tap water which is supplied by the government is within the safety limit.

Tubewell water: There is barely any significant amount of cyanide in the tube well water. The water is fresh and free from cyanide and as a water supply vastly used in this area, is very safe to use. Cyanide which can leech into the ground has not contaminated this part.

Figure 6.1 Turag river bank

6.1.2 Area 1I: Rural Industrial Area Rupganj

Table 6.3 Area survey for Rural Industrial Area Rupganj X Area survey form: 2	
Name of area	Rupganj
Area size	16 km²
Part of Dhaka	
Type of area	Rural and Industrial
Approximate Population	150 thousand
Type of dwellers	Villagers, Workers, Labors
Percentage living in household with tap water supply	About 10%
Main type of housing	Mostly huts or low tin shed buildings
Shop and restaurant density	10 or less
Number of factories	Less than 20
Type of factories	Fabrics weaving and embroidery, wood work, rice and flour mills, agriculture
Main water body	Shitalakshya River
Mostly used water source by percentage	Tap water 15%
	Tubewell 25%
	River/Lake 60%
Exposure or main source of pollution	Pesticides used in agriculture

Table 6.4 Rural Industrial area Rupganj sample analysis results X Rural area Rupganj Results		
Name of sample	Absorbance	Concentration of CN- (μg/L)
Shitalakshya river water	0.051	22.27
Tap water	0.032	12.63
Tube well water	0.008	0.46

Discussion:

Rupganj being mainly a rural part of Dhaka, lacks industries. But in the past 5-6 years a lot has developed due to the availability of a river bank and vast unused area. The main industries include fabrics, garments and textiles. The area is mainly used for agriculture and traditional weaving and embroidery.

Shitalakshya river water: Lack of industries contributing to cyanide pollution is probably the reason the river is not polluted yet. This river is the main source of tap water that the government uses to distribute its water supply. This area has not been polluted yet and the only source of the existing levels of cyanide can be deducted from the use of pesticides in agriculture.

Tap water: Being a rural area, not many houses have proper sanitation system or access to tap water supply. Even though it is not the main source of water, the supply water has cyanide count within limit and can be deduced as safe.

Tube well water: If not river water then tube well is the other main water supply for the people in this area. With a very negligible value of traces of cyanide, it can be concluded that cynide has not leeched into the soil and the tube well water is free from this metal.

Figure 6.2 Shitalakshya river bank in Rupganj

6.2: Area type : Residential

6.2.1 Area I : Residential area Banani

Table 6.5 Area survey for Residential Area Banani

Area survey form:	
Name of area	Banani Gulshan
Area size	km²
Part of Dhaka	West Central dhaka
Type of area	Residential
Approximate Population	
Type of dwellers	All classes of people mostly higher middle class and slum dwellers
Percentage living in household with tap water supply	Around 80%
Main type of housing	Luxury apartments and slum dwelling
Shop and restaurant density	more than 200
Number of factories	none
Type of factories	N/A
Main water body	Banani Lake
Mostly used water source by percentage	Tap around 40%
	Tubewell 30%
	River/Lake 30%
Exposure or main source of pollution	Plastic bag burning in the slums
	Human waste
	Rotten food material

Table 6.6 Banani Area sample analysis results

Table 2: Residential model town Banani		
Name of sample	Absorbance	Concentration of CN- (µg/L)
Banani lake water	0.096	45.1
Tap water	0.061	27.3
Tube well water	0.059	26.4

Discussion

Banani is a residential part of Dhaka consisting of both upper and lower class dwellers. There have been a recent upsurge of restaurant and shops in the area causing more pollution and debris collection in the lake and streets. The area consists of a large slum which takes up almost a quarter of the area and is situated right next to the lake. The lake has a bridge built on it to connect it to another semi residential area Gulshan. This bridge attracts quite a lot of people including street food vendors.

Lake water: The values are within WHO limits and can be claimed to be safe from cyanide toxicity. The higher values for lake water can be a result of a practice of slum dwellers, who live on the bank of the lake, burning plastic bags and bottles which release cyanide into the water. The dense population of slum dwellers near the lake is for easy and free water access and also a waste dump zone. Pollution may reach harmful levels if this is not stopped.

Tap water values are consistent as with all the areas. In this area where every resident has access to tap water and sanitation, only the slum dwellers or homeless require water from river or tubewell.

Tube well water: tube wells are rare in this residential part of Dhaka but were available in the slums. Instead of tap water goverenent has provided them with tube well water for easier acess to clean water. The water here is also within limit but the higher value maybe the result of cyanide leeching into soil from the lake side areas where plastics are burnt, as this particular sample was also taken from that place.

Figure 6.3 Banani-Gulshan lake pollution by plastic and other debris

6.2.2 Area II: Residential area Dhanmondi

Table 6.7 Area survey for Residential Area DhanmondiX Area survey form:	
Name of area	Dhanmondi
Area size	4 km^2
Part of Dhaka	
Type of area	Residential
Approximate Population	120 thousand
Type of dwellers	Middle and upper middle class residents, office goers and daily workers
Percentage living in household with tap water supply	Over 80%
Main type of housing	Multistoried apartments, personal residence and commercial housing
Shop and restaurant density	Around 200
Number of factories	Less than 5
Type of factories	Warehouses, stock brokerage, caterers
Main water body	Dhanmondi lake
Mostly used water source by percentage	Tapwater 80%
	Tubewell 5%
	River/Lake 15%
Exposure or main source of pollution	Unknown

Table 6.8 Dhanmondi Area sample analysis resultsX Table 2: Residential Dhanmondi		
Name of sample	Absorbance	Concentration of CN^- (μg/L)
Dhanmondi Lake	0.023	8.07
Tap water	0.04	16.69
Tube well water	0.008	0.46

Discussion:

Dhanmondi is one of the oldest and largest residential areas in the metropolitan. Like the other residential area Banani this location also comprises of both apartment style buildings and economical households and slums. There are a lot of restaurants and shops. The slums are lesser in number. The lake is part of a park and is kept clean as much as possible. Unlike the other water bodies this lake seems to be significantly less polluted than the rest. There are no industries in this area. Only office and warehouse and even they are less in number. The chances of industries growing into this part of Dhaka is highly unlikely. Hence possibility of cyanide pollution is very low here.

Lake water: compared to the other water bodies this lake has surprisingly low amounts of cyanide pollution. This may be due to the fact that the slum dwellers here do not reside near to the lake. The practice of burning plastic and polythene bags and dumping human waste is scarce. The water here is cleaned from time to time to maintain the quality of the park.

Tap water: Also seen to be relatively same as the tap water in other areas.

Tube well water: is used rarely in this area is free from cyanide as well. There are only a handful of tube wells in the area, almost less than 5.

Figure 6.4 Dhanmondi Lake as part of a local park

6.3 Area type : Industrial

6.3.1 Industrial Area I: Shyampur

Table 6.9 Area survey for Industrial area Shyampur

Area survey form:	
Name of area	Shyampur Kodomtoli
Area size	10.16 km²
Part of Dhaka	South Dhaka
Type of area	Industrial
Approximate Population	1 Lac 80 Thousand
Type of dwellers	Industrial Workers, Daily labors, lower middle class
Percentage living in household with tap water supply	Around 40%
Main type of housing	Economic small houses, apartments, huts and sheds
Shop and restaurant density	less than 30
Number of factories	more than 250
Type of factories	Metal industries, Plastic, Paint, Tannery
Main water body	Buriganga river
Mostly used water source by percentage	Tap around 40%
	Tube well less than 30%
	River/Lake more than 30%
Exposure or main source of pollution	Furnace fires soot
	Tannery wastes
	Metal plating and polishing chemical dumps

Table 6.10 Results for industrial area Shyampur

Table 3: Industrial Area Shyampur		
Name of sample	Absorbance	Concentration of CN- (µg/L)
Buriganga river water	0.165	80.1
Tap water	0.066	29.9
Tube well water	0.049	21.3

Figure 6.5 Dumping tannery wastes in the waters of Buriganga river

Discussion

One of the oldest industrial areas in Dhaka, Shyampur is part of the Old Dhaka city as the main industrial zone. Set on the banks of buriganga it flourished due to the ample supply of water from the huge river. The area has very little residence and those who do live there are local factory workers or staff. There are a lot of factories but very few shops or restaurants. The households are economic style residents and most have access to sanitation and government water supply. There is however a lot of slums which contain a large amount of people living in the outskirts for cheaper rent. These people rely on the river water and tube well supply.

Buriganga river water: has the highest count in cyanide in all of the samples. The levels have exceeded the safety limit set by WHO (0.07mg/L). This can be easily explained by the high density of industries in the area especially ones that have been known to release cyanide such as plastics and dyes, tanneries and metal industries. The waste from these factories are dumped straight into the river water with hardly any form of treatment contaminating with not only cyanide but countless other harmful chemicals. The people exposed are the slum dwellers or homeless using this water for daily use if not for drinking. As shown in figure 6.5, the workers are also exposed to the river waters as part of their daily work.

Tap water: the cyanide levels in tap water are consistent with the values of other locations.

Tube well water: tube well here are of 2 types. One is provided by the government with the same source as tap water, and the other are the ones with underground water supply. Sample was taken from the latter type and analyzed. Values are higher than tube water supplies from other areas. A reason maybe that the cyanide is leeching into the soil from the river water. This is alarming as this water is consumed by people even if the river water is not. Accumulation can cause long term problems.

Figure 6.6 Industrial waste polluting Buriganga River, Shyampur

6.3.1 Industrial Area II: Sonargaon

Table 6.11 Area survey for Industrial area SonargaonX Area survey form:	
Name of area	Sonargaon
Area size	170 km²
Part of Dhaka	
Type of area	Industrial
Approximate Population	300 thousand
Type of dwellers	Lower middle class workers, daily labors and factory staff
Percentage living in household with tap water supply	less than 20%
Main type of housing	Economical buldings, commercial housing for workers, tin shed residence
Shop and restaurant density	less than 50
Number of factories	Around 150
Type of factories	Cement, garments, steel mills, printing and paper mills, textiles, food and beverage
Main water body	Meghna River
Mostly used water source by percentage	Tapwater 15%
	Tubewell 80%
	River/Lake 5%
Exposure or main source of pollution	Wastes dumped from Printing and paper mills,

Table 6.12 Results for industrial area Sonargaon

Table : Sonargaon		
Name of sample	Absorbance	Concentration of CN- (µg/L)
Meghna River	0.091	42.55
Tap water	0.035	14.15
Tube well water	0.022	10.11

Discussion:

Meghna river bank is a platform for industry development in Sonargaon. This is another busy industrial part of Dhaka attached next to the banks of the river Meghna. A lot of industries have sprouted within the last 20 years which include sugar, cement, garments factories, steel mills, printing and paper mills and food and beverage industries. All the dump from these go into the river either processed or unprocessed. Chances of cyanide pollution is low since these industries aren't likely to release or use cyanide except for steel mills and printing presses. But their numbers are very low. Residences are minimal and consist of economical mass housing of workers, daily labors or slum dwellers. There are villages right next to the location and the next part is a rural town.

Meghna river water: Cyanide values are within limit but higher than most. Accumulation over time might cause it to reach alarming levels due to the presence of steel mills and printing presses.

Tap water: value is consistent with other tap water samples and within limit.

Tube well water: Pollution is well below limit and is safe to use. Leeching has not affected, although values are higher than other tube well water samples.

Figure 6.7 Industrial growth around the banks of Meghna River

6.4 Area : Commercial

6.4.1. Commercial Area I: Tejgaon

Table 6.13 Area survey form for commercial Area Tejgaon

Area survey form:	
Name of area	Tejgaon Hatirjheel
Area size	5 km²
Part of Dhaka	Central East
Type of area	Commercial
Approximate Population	1 Lac 80 Thousand
Type of dwellers	Officers, working middle class
Percentage living in household with tap water supply	More than 70%
Main type of housing	Economic small houses, apartments
Shop and restaurant density	more than 100
Number of factories	greater than 25
Type of factories	
Main water body	Hatirjheel Lake
Mostly used water source by percentage	Tap more than 60%
	Tubewell 10%
	River/Lake 30%
Exposure or main source of pollution	

Table 6.14 Analysis results for commercial area Tejgaon

Table : Commercial Area Tejgaon		
Name of sample	Absorbance	Concentration of CN- (μg/L)
Hatirjheel lake water	0.065	29.3
Tap water	0.062	27.8
Tube well water	0.01	1.5

Discussion:

Tejgaon is a busy commercial area in the centre of Dhaka city. Contains a lot of private offices and workplaces but also includes hospitals, warehouse, garments and other types of firms. Residents include all types from large apartments to tin shed housing in some parts. The area also has a lot of restaurants and shops. The lake itself is an attraction site for evening walks or street food vendors.

Hatirjheel lake: the lake is part of the attraction with a bridge built over it. Crowded by street food vendors and consumers alike the lake gets polluted easily by food wastes and plastic bags or bottles. The lake is hardly ever cleaned or maintained and these keep accumulating over time until burnt in a nearby area. The water is not polluted much by cyanide but analysis has shown it to contain high amounts of sulphide shown by lead acetate paper turning black. Cyanide is not the main pollutant here but the water is not safe to use either.

Tap water: The values are consistent with other tap water samples.

Tube well water: tube wells were hard to find in this area as most of the housing had access to clean government water supply. There are probably less than 5 tube wells in this area and only 2 of them actually have water in them. The water sample was free from cyanide. But hardly anyone uses tube well in this area.

Figure 6.8 Pollution in Hatirjheel lake

6.4.2. Commercial are II: Motijheel

Table 6.15 Area survey form for commercial Area MotijheelX Area survey form:	
Name of area	Motijheel
Area size	4 km²
Part of Dhaka	
Type of area	Commercial
Approximate Population	230 thousand
Type of dwellers	Middle and Lower middle class workers, office staff, labors
Percentage living in household with tap water supply	more than 80%
Main type of housing	Multistoried apartments, Economical buldings, commercial housing for workers
Shop and restaurant density	more than 100
Number of factories	less than 5
Type of factories	transport, catering, food and bevarage warehousing and office
Main water body	Ponds
Mostly used water source by percentage	Tap water 85%
	Tubewell 5%
	Ponds 10%
Exposure or main source of pollution	Waste from office, restaurants and shops

Table 6.16 Analysis results for commercial area MotijheelX Table : Commercial motijheel		
Name of sample	Absorbance	Concentration of CN- (µg/L)
Pond water	0.038	15.67
Tap water	0.031	12.13
Tube well water	0.008	0.463

Discussion:

This area is located in the center of Dhaka and is one of the busiest commercial areas in the city. Consists of government offices to private offices and banks this is like a hub of the whole city. The area has very few water bodies and those that existed have been covered up to make more land areas for use. The small ponds that are still available are used as a water source by the homeless or slum dwellers. Contains all kinds of housing systems with access to tap water supply in almost all of them. Factories if any contain food and beverage packing units, transport firms etc.

Pond water: Out of the 3 small water bodies, sample was taken from the largest of them which could be called a big pond. The water there contained as much cyanide content as tap water. These water bodies are parts of small parks and are not used as much by anyone other than the homeless. Even though the water contained very little cyanide there were large amount of nitrates present in the pond water sample.

Tap water: It is consistent with other tap water samples and is well within the limit.

Tube well water: There are hardly any tube wells in the area and those that are availabl are not used by anyone much. Sample was taken from the tube well that seemed to be out of use for a while.

Figure 6.9 Small water body in Motijheel commercial area turned into lake park

Chapter 7: Conclusion

In this project I have tried to cover almost all the areas in Dhaka that can be divided according to the type of region they are and their location in Dhaka city. I have added tap water to the experiment as an added extra for better value comparisons. Although the water bodies in Dhaka are heavily polluted, it seems that so far we are safe from cyanide in drinking water. Every one of the values fall within WHO and EPA recommended cyanide limit and we can safely use this water for our daily use. But till a certain amount of time. The rate at which industries are growing, as can be seen by one of the results which seem to be very different from the others. Those two are the water bodies that are used by the main industries in question who emit cyanide in different forms into the water. Turag River has paper mills, garments industries, brick furnaces and pharmaceuticals located near it using its water. Buriganga has a huge number of steel, iron and other metal industries and wood mills, paint factories. These industries have a lot of burning soot and plastic as well as other wastages that are sometimes burned off. All these have contributed to the distinctly higher concentration of cyanide in these samples than in the others. The people who use these water bodies as their daily source of water, would be the first victims of cyanide poisoning if it ever takes place. The rate at which buriganga is getting polluted is very alarming and the people living in the surrounding areas are the ones in constant exposure to it and will fall victims to cyanide poisoning along with other forms of health hazards due to its heavy pollution. Compared to these two values the others are comparatively low. Especially in tap water the values seem to be consistent in every area. In tube wells the concentration of cyanide is the lowest especially in the rural and residential areas of Dhaka. As cyanide has potential to leech into the ground, there is a high possibility that it can reach tube well water supply if heavy pollution occurs. Commercial and residential area water bodies also have a low count of cyanide which is understandable due to the lack of industries or cyanide emitting sources in the area. Although the availability of tube wells in the city have become close to zero there are still a few that I could find for my research. Most of these have been replaced by the government water supply into the pipes or submersible tanks that go even lower into the ground.

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