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Impact of Sewage Pollution of Matshaya Stream on Weeds Phytosociology: The Case of Antelope Park, Gweru Zimbabwe

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ABSTRACT

Introduction: The disposal of raw or partially treated effluent has led to the proliferation of weeds in pristine water systems such as rivers and streams in the study area.In Gweru raw sewage is also being discharged into streams as blockages occur at Mkoba 4 high density suburb sewage lift pump system, also raw sewage is discharged due to sewer blockages at Mkoba village 11 for more than 25 years. The raw sewage from the lift pump station and Mkoba 11 converge and flow right into antelope park dam. The city's sewer system is very old now and cannot accommodate the ever-increasing population resulting in frequent blockages.

Aims:

1. To Identify water weeds along the discharge point up to Antelope Park dam
2. To classify the water weeds that exist in the study area.
3. To test the physico -parameters of water from discharge point up to Antelope park dam (pH, electrical conductivity, chemical oxygen demand, and dissolved oxygen).
4. To test the nutrient quality of effluent water from point of discharge to Antelope park dam(Sulphates, nitrates, salinity, total dissolved solids and ammonia).

Methodology: Manual sampling was used for collecting grab samples and/or for immediate insitu field analysis. Sampling sites were conveniently chosen as some of the places were inaccessible. Sampling points were geo -corded respectively , Lat-19◦29'5831"S Long-29◦44'36.26"E (sampling point 1) , Lat-19◦3013.49"S Long-29◦44'2591"E (sampling point 2) , Lat-19◦3035'22"S Long-29◦44'4,43"E (sampling point 3) and Lat-19◦30'25.78"S Long29◦43'6,51"E (sampling point 4) .Parameters like temperature, turbidity, salinity, DO, electrical conductivity and pH were tested in situ. For nitrate, phosphorus and COD the sample were preserved using sulfuric acid. Samples were transported to the laboratory [NUST] in an ice cooler box to maintain temperature of less than four degrees. (Changes caused by growth of microorganisms are greatly retarded by keeping the sample at a low temperature (<4°C but above freezing). Pictures of water weeds were captured from point of discharge upto the Antelope park dam.

Findings: Existence of bioindicators plants which depict sewage pollution included Lemnagibba (duck weeds, Water meal, Nymphae odorata (water Lilly), green algae, Potamogeton Crispus L (Curlyleaf), Ludwigia grandifora (water primrose), Typha latifolia, Polygonum pensylvanicum L (Phragmites) all these weeds among others show vivid evidence of sewage pollution taking place at the study area.Weeds were classified into floating, submerged, emersed and marginal. The average concentrations of (Chemical Oxygen Demand) COD of 272.463mg/l in the effluent exceeded the recommended Zimbabwe Standards. The upper limit value for (COD) of effluent water according to EMA is ≤ 200, however this implies that results of the field research shows that COD levels have exceeded the recommended levels hence one can conclude that pollution because of effluent discharge is taking place.Nitrate concentrations had an average of 0.2693. The value has exceeded water quality standard for aquatic life, where quality standards are allowed $N0_3$ is 0.008 mg/l proving that pollution at the study area is taking place.According to the Environmental Management Agency (EMA) standards the permissible value of Dissolved Oxygen, (DO) is ≥ 15 implying that sampling sites 1 – 3 were far below the standard as the sites had utterly no DO.

Conclusion: A myriad of water weeds existing at the various points show that pollution due to sewage effluent is occurring. Pollution is taking place as evidenced by parameters like COD, DO, and Nitrates.

Recommendations: Municipality to engage private and public stakeholders in the funding of waste water treatment. Antelope park authorities to conduct periodic tests of water and rectify anomalies. Advocacy to be offered to tourists and visitors on the status of water quality as some activities like fishing and boat cruising may expose them to infection.

INTRODUCTION

While it is widely recognized that sewage contamination of surface waters is a global threat to public health [1], recent research reveals that water contaminated by sewage pollution can also affect wildlife and natural habitats[2]. The plants and wildlife living in or around contaminated water often accumulate toxins and pathogens found in sewage. For example, juvenile salmon captured within several hundred meters of wastewater treatment plant outfall sites tested positive for more than 40 sewage-borne contaminants[3]. Likewise, heavy metal occurrence in predatory fish is positively correlated with increasing sewage pollution in those waters[4]. Pathogens found in sewage pollution that have been shown to cause widespread disease in humans have recently been shown to cause white-pox disease in the most important habitat-forming coral in the Caribbean[3].

Even in countries with high coverage of modern sanitation facilities, poor design and lack of commitment to maintain infrastructure leads to massive pollution via discharge into surface and ground waters. Annually, more than 4.54×10^9 m^3 (1.2 trillion gallons) of untreated sewage, stormwater, and industrial waste flow into United States rivers because of overburdened treatment systems[3]. Annually, almost 102×10^6 m^3 (27 billion gallons) of untreated sewage flow into New York Harbor alone. With such widespread and intense human waste entering waterways, it is not surprising that global sewage pollution models predict widespread contamination of surface water[2,4,5]

Almost every country likely suffers from severe contamination of surface water by sewage in at least one city, and many countries likely suffer this level of contamination over much larger areas. Waterways within the Los Angeles and San Francisco metropolitan areas, for instance, are predicted to have severe levels of contamination, on par with levels modeled for much more extensive geographical areas in China and India that completely lack sanitation[3]. For high levels of surface water fecal contamination, the extent of contamination of surface waters is predicted to be massive in some countries. All of India fits into this category, as does ~70% of the United Kingdom, and ~30% of the United States, excluding Alaska[3].

Because sewage contamination is a global threat that occurs in most areas where humans live[1] and nature is often nearby, it is possible that sewage also globally threatens natural habitats and biodiversity. Conservationists have traditionally, however, not addressed sewage in their mitigation’s effort[3].

Depending on sewage treatment, contaminants of emerging concern (pharmaceuticals, personal care products, plasticizers, flame retardants and pesticides) can be degraded, removed or released into the environment[6]. The continuous release of pharmaceutical and personal care products has harmful effects on wildlife in the environment[7]. Pesticides such as Thiram and Carbendazim, pollute and affect biodiversity[8], and CSTs are not effective for removing these residues in wastewater [9]. The presence of high concentrations of compounds used as plasticizers called phthalate esters, poses a health risk. These compounds are present in various water sources, reaching them through inappropriate and/or ineffective disposal of sewage effluents[10] and through leaks from landfills without adequate treatment.

High-income countries collect and treat the majority of wastewater worldwide. In these countries, around 70%

of urban and industrial wastewater is treated. Upper-middle-income countries treat only 38%, for lower-middle-income countries the ratio is 28%, while, in low-income countries, only 8% is treated. In developing countries, the release of untreated wastewater remains a common practice due to lacking infrastructure, technical and institutional capacity, and financing. Wastewater management services are generally inadequate, thus wastewater treatment and disposal is a matter of concern that needs to be addressed[11].

Despite the developments in wastewater (WW) collection and treatment, the discharge of untreated WW into the environment remains a constant practice in developing countries (DCs)[12]. from municipal, agricultural, industrial, hospital, and urban stormwater run-off are the bulk sources of water pollution in Africa It has been projected that the quality of various water resources in Africa will deteriorate more in the future, which will continue to increase the burden of diseases and threats to public health and the environment unless urgent action is taken to manage the generated WW appropriately[12]

In Zimbabwe, monitoring and enforcement of groundwater quality and management by catchment councils are inadequate due to financial challenges at the institutional level and low political backing at the national level in dealing with offenders since the role of groundwater falls under the department of ZINWA[13].

The major challenge faced by the City of Gweru is linked to population increase in the City. The rate at which population is increasing outweighs the rate of development within the City. Thus, upgrading of reticulation system is also outweighed or plays a second fiddle after housing. Sewer pipe blockages,bursts and malfunctional sewage treatment facilities add on to the environmental pollution[14].

Problem Statement: It is widely recognized that sewage contamination of surface waters is a global threat to public health[1].The disposal of raw or partially treated effluent has led to the proliferation of weeds in pristine water systems such as rivers and streams in the study area. In Gweru raw sewage is also being discharged into streams as blockages occur at Mkoba 4 high density suburb sewage lift pump system, also raw sewage is discharged due to sewer blockages at Mkoba village 11 for more than 25 years. The raw sewage from the lift pump station and Mkoba 11 converge and flow right into antelope park dam. The city's sewer system is very old now and cannot accommodate the ever-increasing population resulting in frequent blockages. It is against this background that the researchers conducted the study.

Aims:

1. To Identify water weeds along the discharge point up to Antelope Park dam
2. To classify the water weeds that exist in the study area.
3. To test the physico -parameters of water from discharge point up to Antelope park dam (pH, electrical conductivity, chemical oxygen demand, and dissolved oxygen).
4. To test the nutrient quality of effluent water from point of discharge to Antelope park dam (Sulphates, nitrates, salinity, total dissolved solids and ammonia).

Weeds are defined as "plants adapted to manmade habitats and interfered with human impacts"[15]. They are crucial componentsof agro-ecological systems and their population dynamics. Their phytosociology may be controlled by different temporal and spatial scales[16]. Studies of weed communities by a myriad of numerical methods, like as cluster and correlation analysis, and multivariate technique such as canonical correspondence analysis can be a useful technique to reveal relationships between weed species and pollution[17], but using these computerized tools to assess the correlation between weeds communities and the degree of pollution is still lacking. This is where my ignorance supersedes my knowledge hence the need to conduct a study to assess the impact of pollution on weeds phytosociology.

Study area

The city of Gweru lies on a watershed, which stretches from Rusape to Bulawayo and is at an altitude of about 1422 meters. The city of Gweru has only 2 sewage treatment plants which are Outfall works built in 1957 and Cambridgeshire built in 1993.It has also five sewage pump stations which pump sewage to treatment plants and these are Lundi, South view, Mkoba 4, Nashville and Montrose pump stations. All the sewage treatment plants

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are not functional and in addition three out of five sewage pump stations are also not functional and these are contributing to heavy pollution in the Gweru river system, [14]. Mkoba 4 pump station releases its partially treated effluent to Antelope park dam. The water is used for watering loan, flowers and boat cruising. Figure 1 shows the study area map.

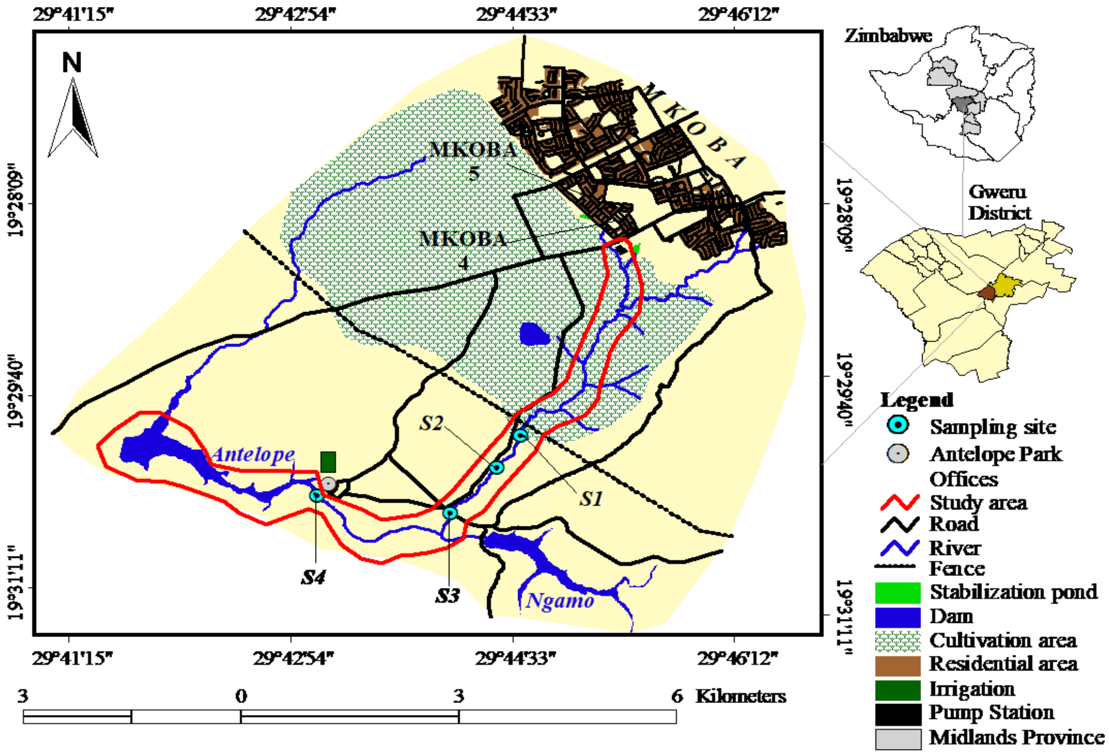

Figure 1: Study area map [Source: Researcher generated]

MATERIALS AND METHODS

Sample collection was a snapshot or once off at point of discharge and at intervals of convenience downstream [Matshaya], sterile 500ml polythene bottles were used for collection. Manual sampling was used for collecting grab samples and/or for immediate insitu field analyses. Sampling sites were conveniently chosen as some of the places were inaccessible. Sampling points were geo -corded respectively, Lat-19◦29'5831"S Long-29◦44'36.26"E (sampling point 1), Lat-19◦3013.49"S Long-29◦44'2591"E (sampling point 2), Lat-19◦3035'22"S Long-29◦44'4,43"E (sampling point 3) and Lat-19◦30'25.78"S Long29◦43'6,51"E (sampling point 4). The samples were collected at various points that is, where the wastewater was well mixed and where it was not well mixed to ascertain different levels of pollution. At each sampling point 2 litres by six samples were conducted. Therefore, the samples were collected near the centre of the flow channel, at approximately 40 to 60 percent of the water depth, where the turbulence was at a maximum and the possibility of solids settling was minimized. Skimming the water surface or dragging the channel bottom was avoided. However, allowances were made for fluctuations in water depth due to flow v Parameters like temperature, turbidity, salinity, DO, electrical conductivity and pH were tested in situ. For nitrate, phosphorus and COD the sample were preserved using sulfuric acid. Samples were transported to the laboratory [National University of Science and Technology] in an ice cooler box to maintain temperature of less than four degrees

Effluent parameters and method of analysis

Site	Parameter	Units	Method of analysis
1 TO 4	pH	NTU	Multimeter
	Electrical conductivity	Micro soviets	Conductivity meter

	Total dissolved solids	Mg/l	Multimeter
	Sulphate	Mg/l	Gravimetric
	Nitrate	Mg/l	Ultraviolet spectrophotometric
	Ammonia	Mg/l	Nitrate
	Dissolved oxygen	Mg/l	Winkler
	Chemical oxygen demand	Mg/l	Titrimetric
	Ammonia	Mg/l	Filtration and titration
	Phosphorus	Mg/l	Ammonia molybdate spectrometric

Sampling sites and location

Site	Location [accuracy as at zero]
1	Lat-19◦29'5831"S Long-29◦44'36.26"E
2	Lat-19◦3013.49"S Long-29◦44'2591"E
3	Lat-19◦3035'22"S Long-29◦44'4,43"E
4	Lat-19◦30'25.78"S Long29◦43'6,51"E

Pictures (plates) were used as aid to explain the existence of the various weeds at varying points on the study area. Naturally occurring Bioindicators were used to assess the health of the environment and are also an important tool for detecting changes in the environment, either positive or negative, and their subsequent effects on human society. There are certain factors which govern the presence of Bioindicators in environment such as transmission of light, water, temperature, and suspended solids. Through the application of Bioindicators we can predict the natural state of a certain region or the level/degree of contamination[18]. The classes of plants are shown in table 1.

Floating plants	Submerged plants	Emersed plants	Marginal plants
Duckweeds (Lemnagibba)	Curlyleaf pond weed (Potamogeton CrispusL.)	Water primrose (invasive Ludwigia grandifora)	Cattail (Typha latifolia)
Water meal	Watermilfoil (Myriophyllumsibiricum)		Smartweed (Polygonum pensylvanicum L.)
Water lily(Nymphaea odorata)			Phragmites
Green algae			

Classification of weeds

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RESULTS AND DISCUSSION

Effluent parameters and results

Sampling site	pH	EC	COD	DO	Sulphates	Nitrates	Phosphorus	Salinity	TDS	Ammonia
1	8.2	156	350.724	0	0.189	0.272	0.3051	684	1.10	8.7241
2	8.7	1602	217.391	0	0.13632	0.2776	0.2637	699	1.13	8,57
3	8.45	1273	228.985	0	0.1019	0.2966	0.3319	550	903	5.3172
4	8.7	378	292.75	16.5	0.07853		0.0472	164	275	1.417

The average concentrations of COD of 272.463mg/l in the effluent exceeded the recommended Zimbabwe Standards. The upper limit value for (COD) of effluent water according to EMA is ≤ 200, however this implies that results of the field research shows that COD levels have exceeded the recommended levels hence one can conclude that pollution because of effluent discharge is taking place.

The result of the field research shows that ammonia levels from point of discharge to anchor yeast dam Antelope Park had an average value of 6.0696 mg/l. According to EMA standards the upper limit value for ammonia is ≤0.3 implying that pollution is taking place.

Nitrate concentrations had an average of 0.2693. The value has exceeded water quality standard for aquatic life, where quality standards are allowed $N0_3$ is 0.008 mg/l proving that pollution at the study area is taking place.

According to the EMA standards the permissible value of D.O is ≥ 15 implying that sampling sites 1 – 3 were far below the standard as the sites had utterly no DO. An average of 0.23698 mg/l was found for the concentrations of phosphates, the EMA upper limit value for total phosphate is ≤5 implying that the concentrations from the study did not exceed the limit.

A mean of 0.1264mg/was found for the concentrations of sulphates, however the upper limit value for sulphates in waste water is ≤ 5 (according to EMA) meaning that there was no pollution as depicted by the study results.

Effluent parameter's mean and Environmental Management Agency Standards [EMA]

Parameter	Range	Mean	EMA standards
pH	8.2-8.7	8.51	12-14
EC	8.73-1273	852.25	≤3500
Sulphate	0.07853-0.189	0.1264	500
COD	217.39-350.724	272.463	≤200
DO	0-16.5	4.1	≥15
Phosphates	0.0472-0.3319	0.26398	≤5
TDS	1.10-903	295.0575	-
Ammonia	1.417-8.974	6.0616	≤0.3
Salinity	164-699	524.25	-

Duckweeds (Lemna gibba)

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Plate 1 shows the duck weeds

Plate 1: Duckweeds Duckweed Lemna gibba

Duckweeds were viewed as very minute plants approximately 0.6mm long and weighing as much as two grains of sugar. Although the individual plants looked like small leaves, they were actually pseudo leaves normally termed fronds. Normally, a single root hung from beneath each individual frond and acted as an active conduit through which the plant obtained its nourishment. Duckweed was found only at the standing waters of the dam.

Meaning that from sampling point 1 to 3 utterly no duckweeds were seen. Duckweeds was seen growing in thick blanket-like mats on still nutrient rich slightly brackish waters of Antelope Park dam.) They are basically monocotyledons of the Lemnaceae family (extrapolated from the Greek word 'Limne', inferring to pond) and are categorized as higher plants or macrophytes, and often mistaken for algae and some taxonomists consider them as being members of the Araceae.

Duckweeds function as nutrient pumps, minimize eutrophication effects and serve as an oxygen source from their photosynthesizing function. Their survival in fast moving water (>0.3 m/sec) is compromised.Their optimumwater temperature for growth is between 6 and 33 ºC[19].

Their voracious reproductive capability can swiftly result in a water body to be completely covered by the green plants in a matter of a few weeks. This does not just impact as an aesthetic problem, but death of fish is very common in ponds screened with duckweeds. These plants may cause complete shading of the water severely limiting explosive photosynthesis by submerged plants and algae. This in turn deprives the given water body of a crucial source of oxygen.

The decay of both aquatic flora and fauna, Oxygen dependant respiration by aquatic plants and animals continues at full strength and intensity, with the final product being significantly lethal low-oxygen levels after several weeks. Duckweeds favour quiet, nutrient rich wetlands and water bodies. High levels of nutrients to "bud"explosively are a prerequisite and thus, are common indicators of water bodies receiving excessive nutrients. Their fragility does not augur well withfast moving water hence almost stagnant water is a requirement for massive plant flourishment[20].

On the contrary, duckweeds are also endowed to absorb and accumulate heavy metals, radionucleotides and metalloids with potential for phytoremediation. The metabolic versatility of duckweeds can be deployed as nutrition in aquaculture, livestock and of late as functional foods. Duckweeds are currently being explored to find new applications in feed to complement diets and increase animal growth either alone or coupled with crop residues to bring about a balance of nutrients,[21].

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Water meal

Plate 2: Water meal

Water meal was relatively smaller than duckweeds, being about 1/32 of an inch in width or about the size of a pinhead. It has no root and obtains nutrients through the underside of the floating frond. Duckweeds, including water meal, generally reproduce by a process called budding in which a new daughter bud is produced every day or so. In two weeks under ideal summer growth conditions, a single parent plant and its subsequent "daughters" can result in the production of up to 17,500 plants. It is this very rapid budding process that allows duckweeds to quickly cover a pond in just a few weeks[22].These weeds were present at the standing waters of the dam and may be considered as evidence of pollution since they thrive in nutrient enriched water bodies.

Water lily (Nymphaea odorata)

Plate 3: Water lily(Nymphaea odorata)

These were seen as floating aquatic plants (boarded by the double black lines), typically found in 3 to 6 feet of water Sweet-scented showy white to pink flowers with many petals. Round, green leathery leaves up to 10 inches across with a slit on one side. Leaves floated on the surface of the water; rarely sticking up above it Leaf stalk attached at base of slit Straight, flexible stalks attached to thick submerged rhizomes. Pond lilly Grew in shallow edges of the dam. They tolerate a wide range of pH; prefers mucky to silty lake/pond bottoms. Dies back in the fall and decays on the water's surface, [23].

Impacts

Spreads quickly and widely: one rhizome can cover up to a 15-foot diameter circle within five years. Fouls boatmotors and restricts passage for non-motorized boats Stagnant mats create mosquito breeding areas and increase water temperatures by absorbing sunlight Contributes to algal growth and water quality problems, [23].

Green algae

Plate 4: Green algae

It was difficult to see individual cells, colonies and filaments, but this was possible as they were concentrated into clumps. These clumps (As illustrated by the black arrows) looked like green flakes, greenish bundles and brownish dots. Algal clumps were only visualized at the standing waters of the dam that is from sampling point number 4 onwards.[24]states that where high levels of phosphorus exist, and other requirements for growth are met – for example, adequate light, mixing, flow and temperature - then the numbers of blue green algae can increase. Increased periods of growth are called blooms. Blooms can have a negative effect on the appearance, quality and use of the water. It may become green, blue-green or greenish brown and several species can produce musty, earthy or grassy odours. Blooms can also cause foaming on the shoreline sometimes coupled with sewage pollution. Blue-green algae photosynthesize during the day, adding oxygen to the water, but consume it at night. This means oxygen levels can be very low in the early morning and can suffocate fish and other creatures. When the bloom has subsided, bacteria causing the decay can also remove large amounts of oxygen.Scrums formed during calm weather when several bloom-forming species rise to the water surface. This looked like paint, jelly forming small clumps. Scums were blue-green, grey-green, greenish-brown or occasionally reddish-brown. The persistence of scum was dependent upon prevailing conditions on the water body. Some formed quickly on calm days, but were rapidly dispersed if wind and wave action increased. Bloom and scum forming blue-green algae can produce toxins. Toxin producing blooms are called Harmful Algal Blooms (HABs).These toxins can kill wild animals, farm livestock and domestic pets. In humans, they can cause rashes after skin contact and illnesses if swallowed, [25].

Algae as bioindicators

Bio indicator organisms can be used to identify and qualify the effects of pollutants on the environment. Bioindicators can tell us about the cumulative effects of different pollutants in the ecosystem and about how long a problem may persist. Although indicator organisms can be any biological species that defines a trait or characteristics of the environment, algae are known to be good indicators of pollution of many types for the following reasons.

- Algae have wide temporal and spatial distribution.
- Many algal species are available all the year.
- Response quickly to the charges in the environment due to pollution.
- Algae are diverse group of organisms found in large quantities.

- Easier to detect and sample.
- The presence of some algae is well correlated with particular type of pollution particularly to organic pollution

Algae of many kinds are really good indicators of water quality and many surface water bodies are characterized based on their dominant phytoplankton groups. Many desmids are known to be present in oligotrophic waters whilst a few species frequently occurin eutrophic bodies of water [26]. Similarly, many blue-green algae occur in nutrient-poor waters, while some grow well in organically polluted waters. The ecosystem approach to water quality assessment also include diatom species and associations used as indicators of organic pollution. One algal specie was selected as indicator of the degree of pollution at Antelope Park dam. Stigeoclonium tenue is present at the downstream margin of the heavily polluted part of the dam, Nitzschia Palea and Gomphonema Parvulum always appear to be dominant in the mild pollution zone whilst Cocconeis and Chamaesiphon are reported to occur in unpolluted parts of the stream or in repurified zone[27]. Navicula accomoda is stressed to be a good indicator of sewage/organic pollution as the species comfortably occur in the most heavily polluted zones in which other species cannot occur. The same hold true for species and varieties of Gomphonema which is commonly found in highly organically polluted water. Amphora ovalis and Gyrosigma attenuatum are also introduced as good examples of diatoms to be affected by high organic content of water [26].

Submerged plants

Curlyleaf pond weed (Potamogeton CrispusL)

Plate 5: Curlyleaf pond weed (Potamogeton crispus L)

This submersed invasive aquatic plant had oblong blue-green leaves that attached to its spaghetti-like stems in an alternate pattern. The margins of the leaves were wavy and fine-toothed. Curly leaf pondweed produced small flowers that were arranged on dense terminal spikes that rose a few inches above the surface of the water. In the spring, the plant produced dormant vegetative propagates known as turions. Turions looked like small greenish-brown pinecones.

Although Curly leaf could provide habitat for aquatic life during the winter when few other plants are present, the negative consequences of this plant far outweigh this one positive aspect. The mid-summer decay of Curly leaf pondweed can cause low oxygen conditions in areas where a considerable amount of decomposition is occurring. The die-off will also cause nutrients to be released from the plants which can trigger algal blooms. Dense beds of Curly leaf reduced recreational opportunities such as boating, and fishing. The most likely mode of introduction of Curly leaf pondweed into a body of water was through the transport of plant fragments on aquatic equipment such as boats and trailers. These fragments can root and create a new infestation. Once the plant is established in a body of water it can spread quickly. Each plant can yield hundreds of turions. Water currents and wave action can transport turions throughout a waterway[16].

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Watermilfoil (Myriophyllumsibiricum)

Plate 6: Watermilfoil (Myriophyllumsibiricum)

The Eurasian watermilfoil grows submerged in water depths of 0.9- 6m .The only parts of the plants that grow out of the water are the flower stalks , which are only a few cm tall .However , the submerged shoots may form a dense canopy right at the water`s surface ,causing the infamous nuisance problem as well as impacting native plant and animal communities.Rooted in the bottom , the root crowns have many stems growing from them up to the surface .Near the surface , each stem may branch multiple times to form a dense mass.watermilfoil does not typically form a branched canopy at the water`s surface and it grows in a more conrolled manner with slower growth and less fragmentation,[28].

Emersed plants

Water primrose (invasive Ludwigia grandifora)

Plate 7: Water primrose (invasive Ludwigia grandifora)

From the observations of the study ,Water-primroses were known for filling in slow-moving waters and surrounding riparian zones. Non-native water primroses sent large numbers of roots deep into soil next to bodies of water. Upon establishment, water primrose grew floating strands, which could stretch as long as 20m onto the water's surface, slowing water and clogging the stream. Water primrose created substantial masses of persistent roots, from which new plants developed. Broken pieces of stem and leaf are also known to create new plants. Stems often take on a reddish tinge, especially in late summer. Leaves are oblong and waxy, with pronounced veins and smooth edges. Most structures are found above water, unlike many aquatic species,[29].The rapid and extensive development of plant populations can block waterways (and thus disturb many human activities such as navigation, hunting, fishing, irrigation and drainage), reduce biodiversity and degrade water quality. Studies done in France have shown that Ludwigia species were able to produce rapidly a high biomass (up to 2 kg of dry matter per m^2). Biomass could double in 15 to 20 days in slow-flowing waters and in 70 days in rivers. As an example, populations of Ludwigia species in Marais d'Orx (France) occupied a few m^2 in 1993 and reached 130 ha in 1998 as evidence of sewage pollution in natural water bodies [30].

Marginal plants

The plates (8,9 &10) show marginal plants

Cattail (Typha latifolia)

Plate 8: Cattail

Cattail Family (Typhaceae) were seen as herbaceous, rhizomatous perennial plants with long, slender green stalks topped with brown, fluffy, sausage-shaped flowering heads. Typha latifolia plants were1.5-3.0m tall. The spike-like, terminal, cylindric inflorescence had staminate flowers above and pistillate flowers below with a naked axis between the staminate and pistillate flowers. The spike was green when fresh, becoming brown as it matures. These plants were rhizomatous and colonial. Cattails were present from the point of discharge all along the banks of the stream and became few in populations as the water reduced its velocity to the dam, [31].

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Smartweed (Polygonum pensylvanicum L.)

Plate 9: Polygonum pensylvanicum L.

Smartweed (black arrow) was seen as an herb that has small, five-parted pink or rose-colored flowers on a short spike. It grew 30cm to 1m high. The stems have a reddish color and swollen nodes. It commonly occurs on mudflats of fresh water to moderately brackish areas hence one can consider it as evidence of pollution by sewage. The alternate leaves have sheaths extending around the stems. The seeds are black, shiny, flattened, and almost pound,[32].

Phragmites

Plate 10: Phragmites

Phragmites (reed) was one of the most widely distributed wetland plant genera on the banks of the stream of the study area. It was characteristic of wet sites, most often with water level ranging from slightly below the soil surface to one meter above ground level and grew mostly at the shores of the dam, along nutrient-rich stream banks. Although reed could grow from seed, vegetative propagation was much more common. It had a strong ability to spread from rhizomes, and parts of rhizomes deposited from moving water could initiate new reed stands. It was a pioneer plant that often occurred in mono-specific stands. [33] supports these findings and state that Invasive Phragmites grows in aquatic, semi-aquatic and terrestrial habitats. It thrives in disturbed habitats, including roadsides and ditches. It prefers standing water found in wetlands, banks, lakeshores, beaches, and wet fields; however, it can survive in low water areas as well.

Odour as indicators of pollution

Smell is another useful, but limited, tool that was considered in combination with other indicators mentioned above. Below are some common smells that result from unhealthy waters. Sulphurous (rotten egg)– A pungent

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sulphurous smell was so powerful at the point of discharge but lost its stenchness down the stream that is at the standing water of the dam it was not as powerful as it was at the point of discharge. The rotten egg smell depicts presence of faecal matter that will be decomposing.

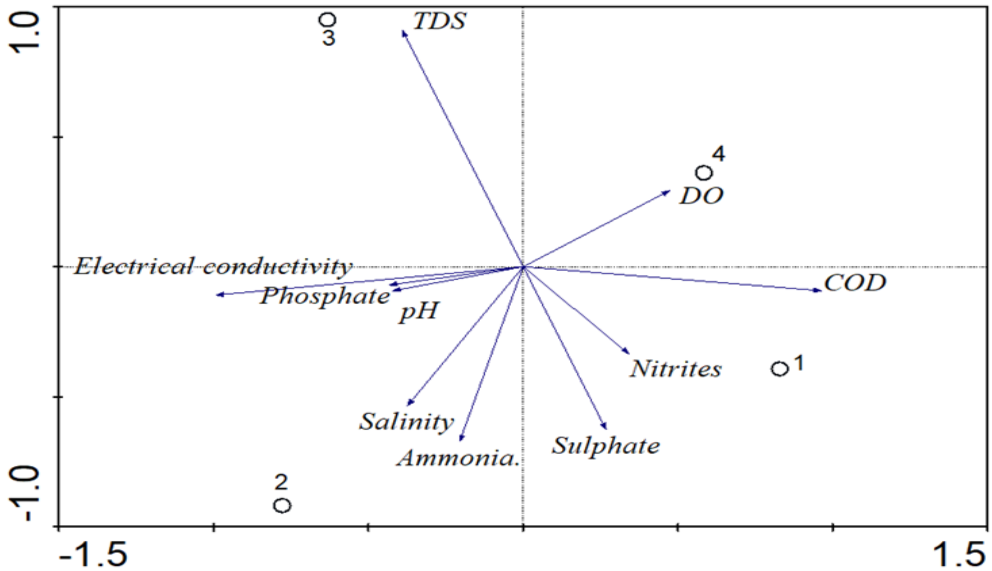
WATER DENSITY

From the observations in the study, sampling points 1 -3 had fast flowing effluent hence there were no macrophytes upon the water surface, however at site number 4 (standing water body) a variety of biomass was observed including algae Scenedesmus quadricauda(green alga),

andfish.[3] explains the density of the water, which allows organisms to live in suspension. Organisms which exploit this are called plankton, and consist of photosynthetic algae (phytoplankton), small animals (zooplankton) which feed on other planktonic organisms and some fish species which feed on other plankton and/or fish. The development of a rich planktonic community depends on the residence time (or retention time) of the water in the water body). Fast flowing water tends to carry away organisms before they have time to breed and to establish populations and, therefore, planktonic communities are more usually associated with standing waters such as lakes and reservoirs.

Principle correspondence analysis.

The researcher used PCA because it simplifies the Identification and elimination of multicolinearities in the data, reduction in the dimension of the input space leading to fewer parameters and \easier" regression.At sampling site 1, the nutrients which prevailed were sulphates and nitrites. These were dependant on availability of COD.At sampling site 2, the prevalent nutrients were, ammonia and phosphate which were dependent on pH, salinity and electrical conductivity. Sampling site 3 had lots of Total dissolved Solids. Sampling site 4 had a lot of dissolved oxygen, which may signify action of weeds in the natural correction of polluted effluent. Figure 2 shows PCA.



Axes	Site 1	Site 2	Site 3	Site 4	Total variance
Eigen values:	0.706	0.238	0.056	0.000	1.000
Cumulative percentage variance of species data:	70.6	94.4	100.0	0.0	

Fig 2: PCA

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CONCLUSION

The prevalent weeds at the study area include, Lemnagibba (duck weeds, Water meal, Nymphae odorata (water Lilly), green algae, Potamogeton Crispus L (Curly leaf), Ludwigia grandifora (water primrose), Typha latifolia, Polygonum pensylvanicum L (Phragmites). The average concentrations of COD of 272.463mg/l in the effluent exceeded the recommended Zimbabwe Standards. COD levels have exceeded the recommended levels hence one can conclude that pollution because of effluent discharge is taking place. The result of the field research shows that ammonia levels from point of discharge to Antelope Park had an average value of 6.0696 mg/l. According to EMA standards the upper limit value for ammonia is ≤0.3 implying that pollution is taking place. Nitrate concentrations had an average of 0.2693. The value has exceeded water quality standard for aquatic life, where quality standards are allowed $N0_3$ is 0.008 mg/l proving that pollution at the study area is taking place.

RECOMMENDATIONS

- The Gweru City council public health department should monitor the status of effluent being discharged into the stream on monthly basis to prevent pollution of natural water sources.
- The city of Gweru Health services department should employ an integrated approach to liquid waste management and rope in private and public partners for financing purposes.
- Antelope park authorities should engage the public Health practitioners to monitor the quality of their drinking water as boreholes are sunk close to the dam where effluent is being discharged.
- Control of the proliferation of invasive weeds should be instituted so that weeds are not spread to other sources of water downstream.
- Antelope park authorities to conduct periodic tests of water and rectify anomalies.
- Advocacy to be offered to tourists and visitors on the status of water quality as some activities like fishing and boat cruising may expose them to infection.
- A study that caters for seasonal variations should be conducted to ascertain the pollution status and growth of weeds.

Key messages

- COD levels have exceeded the recommended permissible limit.
- Ammonia levels are above the minimum limit
- The prevalent weeds at the study area include, Lemnagibba (duck weeds, Water meal, Nymphaeodorata (water Lilly), green algae, PotamogetonCrispus L (Curly leaf), Ludwigiagrandifora (water primrose), Typha latifolia, Polygonum pensylvanicum L (Phragmites).

Conflict of Interest

The authors declare no conflict of interest and the study was on individual funding,no external funding was in cooperated.

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