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Full Length Research Paper

Socio–economic benefits and pollution levels of water resources, Pece Wetland, Gulu Municipality - Uganda

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Communities are dependent on wetlands resources for income generation. However, anthropogenic activities that result into pollution of water are one of the major public health problems. Assessment of socio–economic activities and pollution levels of domestic water sources in Gulu Municipality, Pece wetland was done. The technique for socio–economic data collection was an exploratory method using transect walk along the wetland. Questionnaires and interviews were used. Domestic water sources around the wetland were sampled and analyzed according to APHA (1992). The major activities in the wetland were edge gardening, waste disposal, petty business center called 'Owino' market, water collection for sale, livestock grazing, agro–forestry, brick laying, papyrus harvesting and vehicle washing. The climax of some of the activities was affected by seasons. Over all, the activities contributed to > 50% of the monthly income of the respondents. A section of the wetland seems to be sacrificed for socio–economic activities due to the prevailing insecurity as evidenced in the unclear coordination and monitoring plan for conservation of the wetland. Temperature was not significantly different ($p = 0.672$) and pH was significantly different ($p = 0.000$). The values ranged from 23.4 to 26.0°C and 5.37 to 5.83 for all the water sources respectively. There was significant difference ($p = 0.00$ and $p = 0.03$) in EC and TSS that ranged from 52 to 330 µScm^{-1} and 0.89 to 2.93 mgL^{-1} respectively. Spring water had higher EC and TSS than the boreholes. Faecal coliforms ranged from 14 to 50 CFU/100 ml and was significantly higher ($p = 0.006$) for the spring water than the boreholes. The chloride ion concentration was significantly different ($p = 0.000$) in the water sources and ranged from 89.2 to 331.1 mgL^{-1}. The correlation for faecal coliforms and chloride ions was positive ($r = 0.3577$). The domestic water sources were contaminated, although the assumption in the community is that, boreholes are clean and safe. The communities should be sensitized to treat water before drinking. This could reduce the chances of infection by the pathogenic organisms.

Key words: Benefits, pollution, water sources, wetlands, socio–economics.

INTRODUCTION

Wetlands are hotspots of the areas where they are located by the fact that, they hold a great number of biodiversity (Kipkemboi, 2006). In northern Uganda, wetlands cover an area of 7,065 Km^2 (8.3%) out of the total land area of 85,393 km^2 of the northern region (NEMA, 2002). In Gulu District, Gulu municipality where Pece wetland is located, there is increased encroachment due to rural urban migration in search for security, as well as free and cheap land. The municipality accommodated 22,919 and additional 25,000 displaced persons during the day and night respectively, in the insurgency period (NURP, 1997). Because of the increased population, the pressure on the resources in Pece wetland, that are used for various socio–economic benefits that accrued from the activities in the wetland increased. For that matter, there is need for assessment of the wetlands use to enable proactive rather than reactive management.

In informal settlement where great majority use shallow groundwater, its quality has become a widespread concern for the increased population that come along

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with increased water demand. Each water use including abstraction of water and discharge of wastes, leads to specific and generally predictable impacts on the quality of the aquatic environment (Chapman, 1998) thereby affecting water use. WHO (1996) indicated that almost three quarters of all available drinking water sources in Uganda may be polluted with faecal bacteria and over 73 million work days are estimated to be lost due to diseases related to water. Contamination of water sources by animals or human excreta, introduces the risk of infection to those who use the water for drinking, food preparation, personal hygiene and even recreation (Chapman, 1998). Therefore, effective and sustainable management of water in Africa is very crucial for the economic and social development of one of the world's poorest continent (Nhapi et al., 2005). Water quality criteria, standards and the related legislation are used to manage water quality. The most common national requirements for drinking water of suitable quality by many countries are based on the standards of the World Health Organization (WHO, 1996). The presence and extent of faecal pollution is an important factor in assessing the quality of water source, because it provides information on the health of the water body (Younes and Bartram, 2001; Mintz et al., 2001).

The relatively large population of urban poor that emerged around Pece wetland, resulted into high human densities that used poorly constructed pit latrines and faecal disposal in the surrounding. A section of Pece wetland is used by the National Water and Sewerage Cooperation (NWSC) for tertiary treatment of effluent (partially treated waste water) from stabilization ponds. The domestic water sources (springs and boreholes) could be contaminated as a result of seepage from the pit latrines, effluent from stabilization ponds, and the storm waters from the municipality. This study therefore assessed the quality of the domestic water sources and the socio–economic activities along and within Pece wetland.

MATERIALS AND METHODS

Study area

Pece wetland is an urban wetland located in the northern part of Uganda in Gulu Municipality, Gulu District (Figure 1). The wetland covers the eastern part of the municipality, forming Pece drainage (in Laroo and Pawel division) that link up Gulu Municipality and Aswa River. The springs and boreholes are located within and approximately 100 m away from the wetland edge respectively. These serve as domestic water collection points for the displaced population living in the area.

Study design

The study was both qualitative and quantitative, and intended to establish the level of pollution in domestic water sources and the socio–economic activities within the wetland. These were accomplished by on site observation, *in situ* measurements and laboratory analysis. The technique for socio–economic data collection was an exploratory method, using transect walk along the wetland. Questionnaires and interviews covering views on water and wetland activities were used because most of the target population could read and write. Questionnaires for illiterate respondents were posed through an interpreter and the responses noted. The respondents were the people that were found working in the wetland and stakeholders responsible for environmental management at the district and community level. There were thirty five (35) respondents, constituting thirty (30) individuals who were found working in the wetland, two (2) local council one environment committee members, and three (3) district officials directly involved in environmental management.

Water sampling and field observation

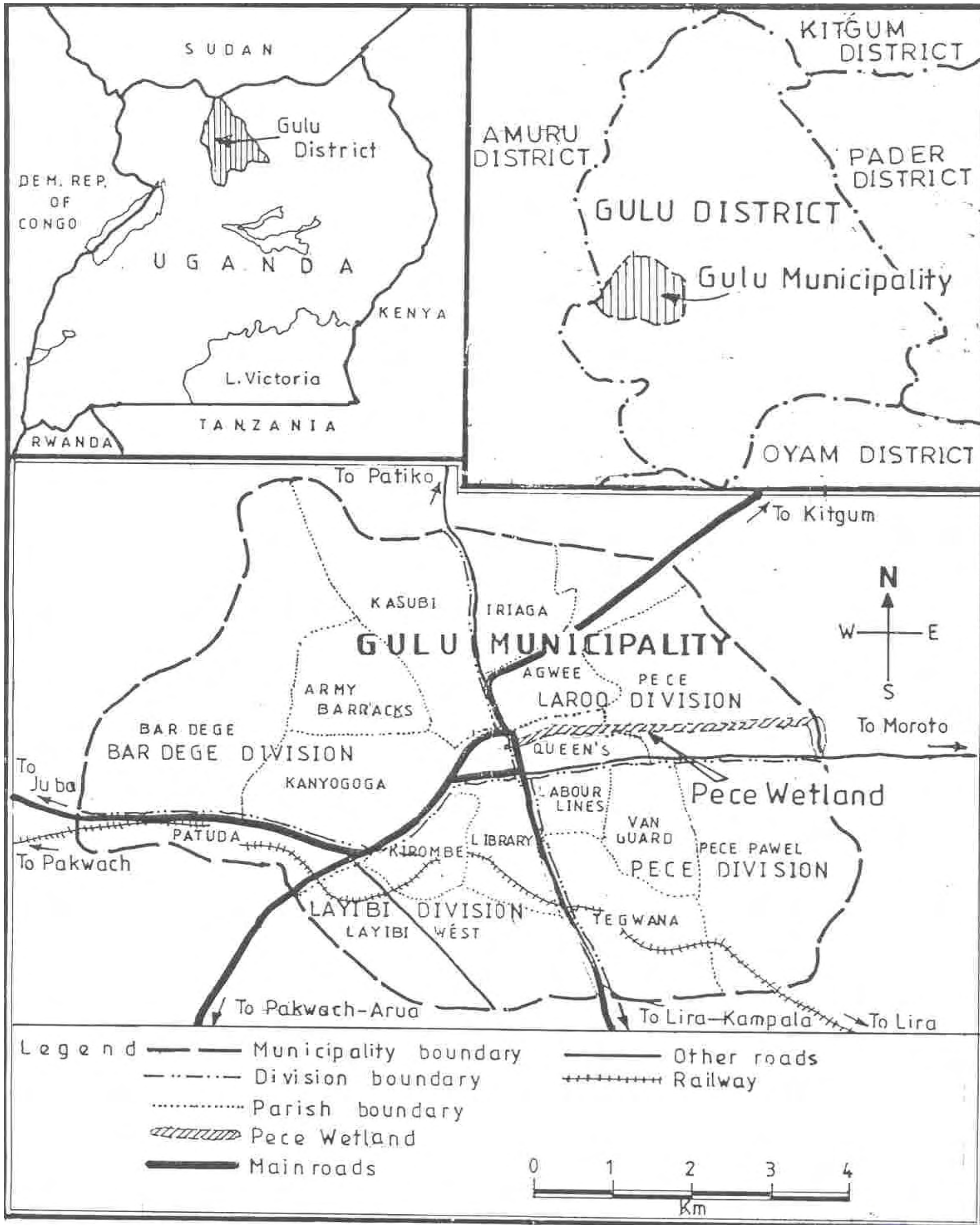
The six (6) sampling sites included three boreholes (B1, B2 and B3) and three spring sources (P1, P2 and P3) (Figure 2). These were the major water collection points in the area. Water samples were collected in mid march to early June, 2008 which was a period of transition from the dry to the wet season. All water samples for bacterial analysis were collected aseptically. Clean sterilized screw capped glass bottles (250 ml) were used for collecting water samples for bacteriological analysis. Water samples for physico-chemical analysis were collected in clean 500 ml plastic bottles that were pre – washed with dilute hydrochloric acid. The sample bottles were first rinsed with the water before collection. Water samples were later transported to the laboratory in an ice box and analysis was done within 6 h for the bacteriological indicators and total suspended solids (TSS). Chloride analysis was done after a day of refrigeration.

Temperature measurements were done in the field by dipping a thermometer in about 20 cm^3 of water collected in the test tube. Water temperature was recorded following the rise of the mercury to a steady level. On - site observations were done, to assess the environment of the water collection points. The distance of pit latrines from the springs and boreholes was estimated, and the sanitary conditions around the water sources were also noted.

Laboratory analysis

Water sample analysis was according to APHA (1992). Faecal coliforms analysis was done in the National Water and Sewerage Cooperation (NWSC) Laboratory, Gulu Branch, using the membrane filtration technique. A sterile membrane filter (0.45 mm) disk was placed in the sterilized holding apparatus. 100 ml of water was passed through the filter disk, so that the bacteria present in water samples are retained on the filter disk. The side of the funnel and membrane were rinsed with sterile distilled water. Thereafter, the membrane filter disk was aseptically removed by a sterile forcep and placed on absorbent disk saturated with culture medium (lauryl sulphate) contained in a Petri dish. The medium passed through pores of membrane and nourished the bacteria present on it, during the incubation at 44°C for 18 h. After incubation, the colonies of yellowish colour that had grown were counted.

To 20 ml of water sample in volumetric flask, two (2) drops of potassium chromate was added as an indicator. This was then titrated using a standard solution of 0.004 M $AgNO_3$. Precipitate of silver chloride was formed. The equivalence point was reached when the slight excess of Ag^+ ions reacted with the indicator (K_2CrO_7), and turned red. At this point, the burette reading was recorded. The procedure was repeated three times and the average volume of silver nitrate was computed and concentration (mg/l) of chloride ions in the sample was calculated. The pH and electrical conductivity (EC) were determined in the laboratory using a pH meter, model LT – 14 and digital conductivity meter respectively.



Source : Gulu District Administration Offices.

Figure 1. Location of Pece wetland in Gulu Municipality.

TSS was determined by gravimetric method. The sample was filtered through a pre–weighed dried filter paper and the weight after filtration was determined. The difference in weight was used in computation of TSS in the water samples.

Data analysis

Statistical analysis was done using Minitab software, Release 13 for windows. One way multiple comparison (F-test) was used to

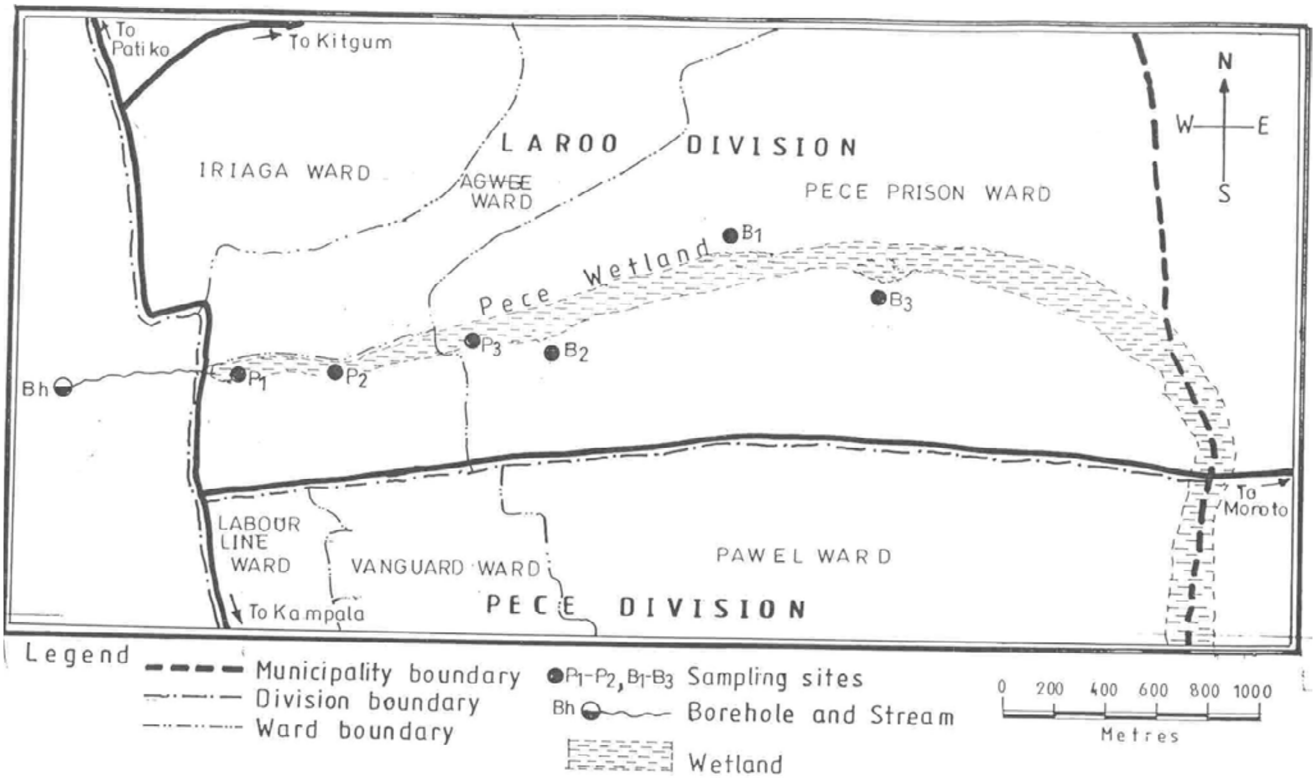


Figure 2. Location of water sources / sampling sites in Pece wetland.

assess overall differences between the means of the variables at the different water sources. Family error rate was automatically adjusted. Data were tested for equal variance and normality using Bartlett's and Levene's Tests, and Anderson Darling Test respectively. All data that did not conform to the requirements were transformed. Statistical comparison for each variable for all the sites are represented by superscript letters a and b and were determined at 0.05 level of significance. Differences in the letters indicate significant difference.

RESULTS

On - site observations revealed that springs (P1 and P3) were fairly constructed and had storm water drainage channels that were maintained by de–silting. However, the channels were poorly constructed. P1 had undersized storm water diversion channel (drainage) as a result, storm water always drained into the water collection point. Unlike P1, P3 had a pipe that directed water into a small reservoir (ditch). Plastic containers were used for drawing water from the reservoir. The containers were not very clean. The sites (P1 and P3) were also characterized by permanent buildings and there were ongoing construction activities. Vehicles were washed at P1 (approximately 10 m away). Unlike P1 and P3, spring (P2) was poorly maintained and was without storm water diversion channel (drainage). The surrounding (P2) was also characterized by rubbish. Pit latrines in all the sites were poorly constructed. The nearest pit latrines were 6, 20 and 30 m from P2, P3, and P1 respectively.

The surrounding of the boreholes was relatively maintained by slashing. However, sanitation was relatively poor. The nearest pit latrines from the bore-holes (B3, B2 and B1) were 5, 24 and 80 m respectively. The number of pit latrines was highest around B2. The region of the wetland, close to borehole (B2) is used for tertiary treatment of effluent from National Water and Sewerage Cooperation (NWSC) stabilization ponds. The surrounding of borehole (B3) was similar to that of borehole (B2). Goats and cattle were found near the water sources (P1, P3, B1 and B2) and their wastes littered the surrounding. It was reported that the animals make the water turbid during drinking.

Variation of physical and chemical parameters of the water sources

The physical and chemical parameters of the water sources are presented in Table 1. Temperature was relatively uniform for the water sources with the range from 23.4 to 26.0℃ for all the sites and mean of 25.18℃ (n = 30). The lowest temperature was observed at P3 which ranged from 24 to 25℃ (n = 5) and the highest values was at B1 (25 to 26℃, n = 5). Statistical analysis

Table 1. Mean ± standard error of the physico-chemical variables of the water sources. Statistical analysis of the variables for the sites is shown by the superscript letter (a and b). Differences in the letters indicate significant difference ($p < 0.05$).

Sites	Temperature (°C)	pH	EC (µS cm^{-1})	TSS (mg/L)
P1	25.35 ± 0.3a	5.54 ± 0.03b	279 ± 26.7a	2.72 ± 0.10a
P2	25.22 ± 0.6a	5.75 ± 0.03a	274 ± 11.2a	2.65 ± 0.13a
P3	24.67 ± 0.3a	5.68 ± 0.07a	144 ± 3.8b	1.71 ± 0.07b
B1	25.37 ± 0.2a	5.41 ± 0.03b	95 ± 1.3b	1.24 ± 0.07b
B2	25.17 ± 0.3a	5.53 ± 0.04b	55 ± 1.4b	0.99 ± 0.05b
B3	25.27 ± 0.1a	5.70 ± 0.07a	76 ± 1.3b	1.22 ± 0.03b

revealed that the mean value of temperature was not significantly different (p = 0.672) for the sites. The pH ranged from 5.37 to 5.83 for all the water sources with mean of 5.6 (n = 30). The lowest pH was observed at B1 with the range of 5.37 to 5.48 (n = 5) and highest at P2 that ranged from 5.67 to 5.82 (n = 5). Analysis of variance for pH indicate that, the mean values were significantly different (p = 0.00) for the sites.

EC values ranged from 52 to 330 µS cm^{-1} with the mean of 153.9 µS cm^{-1} (n = 30). The lowest values of EC was observed at B2 with the range of 52 to 58 µS cm^{-1} (n = 5) and the highest at P1 with the ranged of 202 to 330 µS cm^{-1} (n = 5). EC values were significantly different for the water sources (p = 0.00). TSS values also showed a big variation that ranged from 0.89 to 2.93 mg L^{-1} with the mean of 1.7475 mg L^{-1} (n = 30). Sites P1 and P2 showed the highest values of TSS that ranged from 2.32 to 2.93 mg L^{-1} (n = 10). B2 showed the lowest TSS that ranged from 0.89 to 1.69 mg L^{-1} (n = 5). TSS showed significant difference between the water sources (p = 0.03).

Faecal coliforms and chloride ion concentration in the water sources

The variation of the faecal coliforms and the chloride ion concentration are shown in Figure 3. All the water sources were contaminated with faecal coliforms and chloride ions. The number of faecal coliforms ranged from 14 to 50 CFU/100 ml with the mean of 29 CFU/100 ml (n = 30). There was significant difference of faecal coliforms in the water sources (p = 0.006). Multiple comparisons of water sources showed significantly higher contamination for spring water than boreholes ($p < 0.05$). However, the borehole water sources and spring water sources had similar faecal coliforms values respectively ($p > 0.05$).

The chloride ion concentration was in the range of 89.2 to 331.1 mg L^{-1} for all the water sources with mean of 185 mg L^{-1} (n = 30). The lowest value of chloride ion concentration was observed for B1 with range of 89.2 to 102 mg L^{-1} (n = 5) and the highest concentration was at P2 with range of 316 to 331 mg L^{-1} (n = 5). There was significant difference in the chloride concentration (p =0.00). Statistical analysis (multiple comparisons) of the different water sources indicated that spring water sources had more concentration than the boreholes ($p < 0.05$). The correlation value was positive for the pooled faecal coliforms and chloride concentration for all the sites (r = 0.3577).

Socio–economic activities in Pece wetland

Most of the wetland was degraded and converted into agricultural land, waste disposal ground, agro-forestry and business area called 'Owino' market for petty second hand dresses and shoes. Water quantity and quality, and the water flow in the wetland have been affected by drainage and filling that paved way for the construction of semi permanent houses in the 'Owino' market. Flooding in the area is now common because of the blockage of the natural water flow. The change in the vegetation type was also highlighted by some individuals that have stayed in the surrounding for over ten (10) years. The sedges that used to dominant are no longer in existence.

The economic activities of the people included water collection for sale (20%), edge gardening (30%), livestock grazing (17%), agro-forestry (10%), brick laying (10%) and vehicle washing (13%). These percentages (statistics) exclude the petty business community ('Owino' venders) and those who harvested papyrus. Although no person was found harvesting papyrus during the visits, there was evidence of cut papyrus, that were spread to dry in the wetland. The domestic water collection points were the springs and boreholes. No charge was levied for water collection from these points. The water sources subsidized spending on National Water and Sewerage Cooperation (NWSC) water stand points. An average of 76 L day^{-1} of water was used in a family; estimated at 100 shillings per 20 L. Generally, water cost was the same irrespective of the source (NWSC, spring and borehole).

The people that were found farming in the wetland were from the village of Kony–paco (26.7%), Limo (26.7%), Forest (16.7%), Pece–lokung (16.7%), Awere (6.7%) and Green valley (6.7%). These were the displaced people (immigrants) that were driven off from

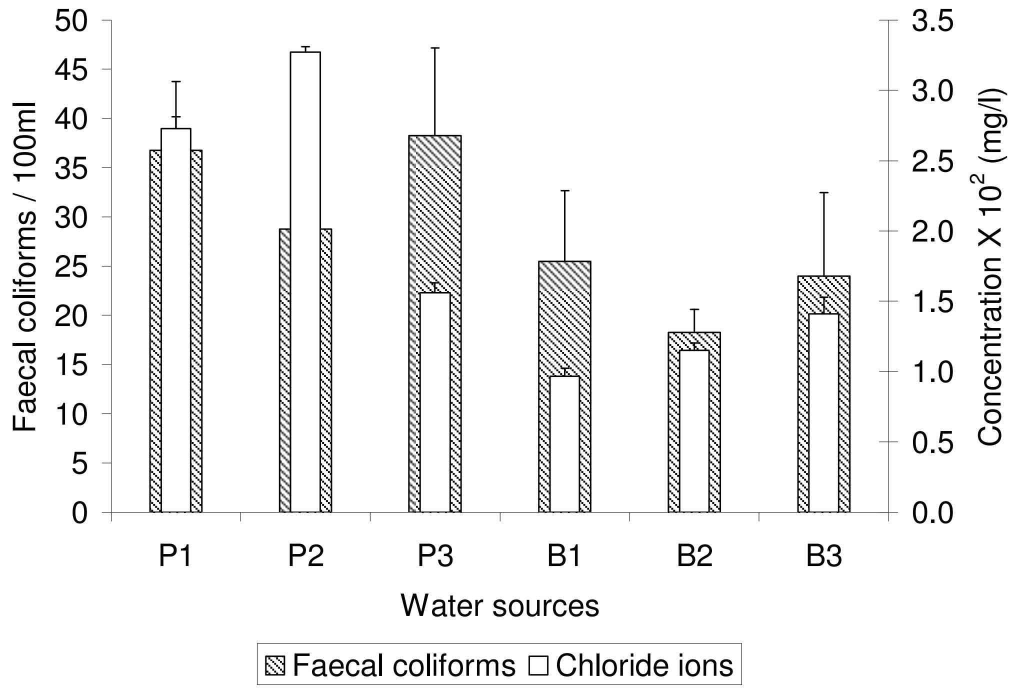


Figure 3. Faecal coliforms and chloride ion concentration in the water sources.

Table 2. NFA nursery tree species and the selling prices (Uganda shillings)

Tree species	Common name	Price per seedling (Uganda shillings)
Mangifera indica	Mango	2,500
Carica papyra	Paw paw	3,500
Pasiflora edulis *	Passion fruit	1,000
Pinus caribaea var hondurensis	Pine (Australia)	300
Pinus caribaea var hondurensis	Pine (Brazil)	250
Pinus caribaea	Pine (Big pots)	1,000
Eucalytus spp	Kalitusi	100

The price list was for the period January to June, 2008 at NFA nursery site. * Grafted plant.

their ancestral land due to the Lord Resistance Army (LRA) insecurity, and now settled around the wetland area. Farming was practiced in both wet and dry seasons. Crops grown were coco yam, sugarcane, cabbage, sweet potatoes, maize, millet and cowpeas. Few crops (coco yam, sugarcane, cabbage) were grown in the wet season. This was attributed to flooding that often destroyed the crops. Crops were sold in the local market. However, some of the produce was consumed by the respective families. Cattle were commonly found at the wetland edge. The average number of cattle grazing during the field visits was twenty one (21) day^{-1}. The wetland provided water and grass throughout the year. A few cattle were tethered with ropes of about eight (8) m, to restrict their movement while others were free range. The free range cattle were monitored during grazing, in order to avoid encroaching into gardens. Destruction of crops by stray animals (cattle and goats) was compensated by the animal owner. In circumstances where compensation was not done, it was acceptable for the crop owner (farmer) to own the animal.

The agro–forestry enterprise belonging to the National Forestry Authority (NFA) employed fifteen (15) causal labourers. Each of the causal labourers was paid fifty thousand (50,000) shillings per month. All workers at the nursery site were immigrants. An average of 160 L day^{-1} of water was used at the site. Water was collected from a ditch in the wetland. The number of the causal labourers fluctuated and was highest during the establishment of nursery beds. Nursery beds were majorly established during wet season. This was attributed to the reduced water usage as the soil is wet.

Table 2 shows the tree species and their costs at the NFA nursery beds. Few of the species (pines and

Table 3. Percentage contribution of wetland activities to monthly household income.

Activities	Percentage range
Water collection	1 – 25
Edge gardening	25 – 50
Cattle grazing	25 – 50
Agro–forestry	50 – 100
Brick laying	25 – 75
Vehicle washing	50 – 100
‘Owino’ business	25 – 75

mango) were grown by the surrounding community. The cost of seedlings depended on the demand. An authority in NFA estimated total income of 1.8 and 2.5 to 2.8 million shillings in every month from the sales of seedlings (Brazil and Australia respectively). An average of thirty thousand (30,000) seedlings was developed from 1 kg of seeds of pine (Brazil or Australia) amounting to 7.5 and 9 million respectively. Seedlings take 3 months to develop into market size, thus affecting income of the respondents.

Brick laying was done towards the end of wet season to avoid damage and the activity involved family labour. Burnt brick costed 100 to 120 shillings depending on the size. A pile of burnt bricks contained 8,000 to 10,000 bricks. A gross income of 800,000 to 1,200,000 shillings was obtained from bricks.

There were only two points for vehicle washing. This activity was restricted in the area due to the probable pollution by oil spillage. Five (5) vehicles were washed by each individual in a day. However, the number of vehicles washed increased during the dry season. This was attributed to the dusty roads. The charges for vehicle washing depended on the type. The cost ranged from 1,000 to 5,000 shillings. Heavy vehicles were sometimes jointly cleaned. The preferred detergent for washing vehicles was ‘Omo’ powder.

The contribution of the socio–economic activities to household income is presented in Table 3. The percenttages were computed from the total income derived from wetland activities and expressed to the total monthly income of the individual households. The annual income obtained from brick laying and agro–forestry was spread over the twelve (12) months. This was then considered to be the monthly income. It should be noted that agriculture and brick laying activities were not done throughout the year due to the seasonal influence. There were also some cross cutting activities, as a result of hired labour force. In general, the activities had a major contribution to the monthly income of the respondents. Some of the respondents fully depended on the wetland activities (> 75%). Overall, 50% of the monthly income of the respondents was from the wetland activities. This is because most of the respondents were hired casual labourers.

DISCUSSION

Despite part of Pece wetland being within gazetted forest reserve, the wetland has been reclaimed as a result of agricultural activities and urbanization. The original vegetation is hardly there anymore in some section, it has been cleared to give way for urban development in some areas (NURP, 1997). This was done by vendors with approval of the Municipal Authority. Agricultural activities mainly practiced by the displaced individuals also contributed to the vegetation change. National Wetlands Conservation and Management Programme (NWCP) (2000) listed a number of social changes contributing to wetlands encroachments in urban centers. Industrialization and urbanization, and lack of knowledge and understanding of the functions and values of wetlands at the political and community level were among others. Pece wetland could be categorized under ‘victim’ wetland. ‘Victim’ wetlands are dispensable wetlands that are ‘sacrificed’ or traded off for other socio–economic development uses e.g. agricultural or urban development (WID, 2003). The low surveillance of urban wetlands by District Environment Officer (DEO), District Wetland Officer (DWO) and the District Agricultural Officer (DAO) is evidence that, there are no regulatory activities to conserve the wetland. There is lack of pressure from the District Environment Committees that are responsible for coordinating, monitoring and advising District Council on all aspects of wetland resource management. This could be attributed to the sympathy for the displaced people who lack land for resettling. According to the National Environment Regulations (2000), the local environment committees are the implementing organ in conserving and managing wetland resources in their area of jurisdiction. There is also insufficient political will, support, commitment and conviction by the government (NEMA, 2002). In addition, there are still contradictions and tensions existing where policy and legislation affecting wetlands are concerned (Kansiime et al., 2005). For example, there is ambiguity surrounding the concept of Government or Local Government holding wetlands ‘in trust for the people’ and confusion over rights and obligations of ownership.

It should be noted that participation of communities in natural resource management takes many forms (Barrow and Murphree, 1998) and is driven by socio–economic factors. The socio-economic circumstances that prevail in many countries’ water resource base and the environment, and the sustainability of the water resources is largely induced by human activities (Madulu et al., 2003). Therefore, the remaining resources in Pece wetland when sustainably used will continuously enrich the life of the surrounding community that is composed of displaced people that depend on hand outs (relief aids). Physical environment influenced by seasons affect levels of the socio–economic activities. In Pece wetland, agricultural activities are attributed to differences in the tolerance of the crops to water logging condition.

People as seasonal opportunists encroach on wetlands to grow crops like potatoes that are not drought resistant, to back up their food supply during the dry season (Kansiime and Nalubega, 1999). Growing of crops in Pece wetland was to supplement the food demand for the displaced people. The vehicle washing and livestock grazing during the dry season is attributed to vehicles getting dirtier and fodder growing in the wetland respectively. Brick laying activity during the dry season enhances drying and reduces loss of wet bricks, that would occur in heavy rain. Senzanje et al. (2005) reported that, with the ever increasing population and demands, there is going to be more pressure on the water resources, requiring an increase of water supply by at least 25%, to meet the basic water needs.

Therefore, a proactive planning is important if Pece wetland water resources are to be conserved. Gleick (1996) recommended that international organizations, national and local governments, and water providers adopt a Basic Water Requirement (BWR) standard for human needs of 50 liters per person per day and guarantee access to it, independently of an individual's economic, social, or political status. In this study, results show that the average amount of water (76 L per household) consumption is below the required standard. In 1990, the total domestic water use as percentage of the BWR of 50 liters per person per day was 19% in Uganda. The situation seems to have declined in Pece area in the subsequent years. This could be attributed to inadequate efforts to improve access to water, sudden population upsurge as a result of insecurity resulting into overcrowding in the area. However, the government, water providers, and international aid organizations are struggling to overcome that.

The contribution of the socio–economic activities in the wetland to the household income of the respondents was enormous (overall > 50%). According to Mafabi et al. (2005), numerous studies found that it is often the poorest households, that are most dependent on natural resources for income generation through jobs and small enterprises. In principle, the use of wetlands for agriculture, fisheries and livestock production systems for subsistence and income generation is acceptable to the Ministry of Agriculture, Animal Industry and Fisheries in Uganda (WID, 2003). Though human population live and work on the land for their survival, they respond differently to emerging environmental changes, including changes on water resources accessibility (Dungumaro and Madulu, 2003). In addition, the change such as poor water quality has the greatest impact on marginalized communities and those that lack political and economic power (Palaniappan, 2010). Lower economic productivity of agriculture as a result of polluted water is observed in destruction of crops, reduction in crop quality and diminished yields (Palaniappan, 2010). Therefore, the implication of area specific (Pece wetland) problems and solutions cannot be neglected.

The slight change of temperature is unlikely to have caused the observed variations amongst the domestic water sources in reference to the distribution of indicator organisms. However, lower pH levels are explained by the ground water influenced conditions, saturated with carbon dioxide. According to Baneji (2004), high values of EC show that the water is polluted. Erosion and anthropogenic disturbance could have contributed to the TSS in the spring waters (Chapman, 1998; Nsubuga et al., 2004) as evidenced in the spring that had poor storm water diversion; that notwithstanding, the disturbance by animals during drinking cannot be ruled out. Indicator bacteria (faecal coliforms) and chloride concentration have been confirmed in the water sources, and were higher compared to WHO standards for drinking water (WHO, 2004). This is an indication of human or animal faecal material contamination. The contamination level was much higher in springs compared to the boreholes. The workmanship for spring water sources was poor and rudimentary. There was poor drainage channel, and storm water from the catchment drained directly into the water collection points. Such water sources therefore are not suitable for human consumption unless treated. According to Byamukama (1998), the presence of high levels of faecal coliforms in water, implies the presence of high levels of pathogens. Younes and Bartram (2001) indicated that pathogens in water cause diseases such as diarrhoea, cramps nausea, headaches or other symptoms. Nsubuga et al. (2004), and Younes and Bartram (2001) indicated that, constant exposure to pathogens result in water borne disease outbreaks and continuous presence of infective micro - organisms in the population, leads to poor health and low productivity of the community.

Chloride concentration is usually lower than 10 mg L^{-1} and sometimes less than 2 mg L^{-1} in freshwater but higher concentrations can occur near sewage and other waste outlets, irrigation drains, salt water intrusions, in and out of wet coastal areas (Chapman, 1998). Chloride concentration is used as a convenient indicator because chloride is stable and is relatively a non - reactive inorganic constituent, and high concentration can make waters unpalatable and therefore unfit for drinking or livestock watering (Chapman, 1998). However, determining the concentration of chloride in water if present, does not necessarily mean the water has faecal contamination because the chloride may be from different sources. In this study, the positive correlation (r = 0.3577) of chloride ions with faecal coliforms could indicate the same origin of the contaminants. This is attributed to the highly dense population in the informal settlement that use poorly constructed pit latrines, sewage effluent from the stabilization ponds and poor sanitary conditions in the vicinity of the water sources.

The impact of the rain was reflected in faecal coliform data sets (water samples) that were immediately collected after rain. However, seasonal effect was not reported in this study. Howard et al. (2003) showed that rainfall run-offs are causes of microbiological contamination of shallow ground water in Kampala, Uganda. Nkhuwa (2003) also reported that biological and chemical water content varies with season and locality. Rainfall has been demonstrated as a major factor in pollutant transport into protected springs, boreholes, wetlands and seepage into the ground water supply (Hadii, 2007; Nsubuga et al., 2004). More studies have shown very rapid response to rainfall events, with changes noted within hours (Barret et al., 2000). The causes of poor quality of the domestic water sources, appear to be primarily related to the poor maintenance of sanitary completion measures around the water sources (Howard and Luyima, 1999b) and the use of backfill media, that offer little in the way of filtration and attenuative capacity (Howard and Luyima, 1999a). This was clearly observed for spring water sources P1 and P2. The hazards such as pit latrines may have less effect, although could be important at certain sites.

CONCLUSIONS AND RECOMMENDATIONS

Pece wetland could be categorized under 'victim' or dispensable wetlands that are 'sacrificed' or traded off for other socio–economic development uses. The domestic water sources were contaminated, although the assumption in the community is that boreholes are clean and safe.

As a temporary and quick measure, the communities that use the water sources should be sensitized so as to treat water for drinking (boil or use water guards). The research findings also express the need for reconciliation between human activities and the underlying geology and hydrology in order to preserve an environment that promotes and perpetuates good human health.

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