THE ECONOMIC EFFECT OF HARTBEESPOORT DAM AREAS

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ABSTRACT

Hartbeespoort Dam water is the main sources of water for recreational, irrigating crop, and drinking purposes. The study aim was to assess the economically effects around Hartbeespoort Dam area. Sources water were analysed for the microcystins contamination. Economically data around the study area were reviewed. The findings are that crops farming, recreational and drinking water quality are affected by the high concentration of cyanotoxins in water, however, there is significant increases in an economy due to major tourist attraction and the opportunities offered for water activities, mountain sports, aquarium, snake park and cableway. Activities around the Hartbeespoort Dam has positive effect on economy.

Keywords: Hartbeespoort dam water, economic, water contamination, Cyanobacteria.

INTRODUCTION

The Hartbeespoort dam area is situated in the middle of the beautiful Magaliesberg Mountain, which are few kilometres away from South African economically harbour province Gauteng. The 213 m^2 Hartbeespoort dam water is supplying 130 square km irrigation water schemes and more than 22 000 population around the area with drinking water (Harding et al., 2004). The beauty of the area makes property development to take place in there.

The challenges of the Hartbeespoort dam is that is one of the most water contaminated dam with cyanobacteria in the world (Oberholster and Ashton, 2008). The cyanobacteria which is also known as blue-green algae produce toxins in its surround such as water. The algae grow well in the dam due to the favourable conditions such as warm temperature, calm wind and enough nutrients. South African condition in summer is perfect for the cyanobacteria to grow as it reach the average of 39°C, heavy rain falls that washes fertilizers from agricultural farms into the dam and water calm condition (van Ginkrl, 2011). One contributing factors is the poor waste water sewage in the northern part of Johannesburg that resulted in dark water run into the rivers such as Jukskei and Crocodile river which end up in the dam (Roux and Oelofse, 2010). All these factors contribute on the blooming of the cyanobacteria in the water. During the blooming season the cells become stressed as they compete for the resources, due to this stress the cells release toxins. The acceptable limit of the toxins in drinking water is 1 µg/L. The cells also releases toxins during the dying or decaying off (Gélinas *et al.*, 2014).

Hartbeespoort Dam area is one of the South African areas that is blooming with the businesses of tourists and property developments because of the recreational activities. It is a major tourist attracting and it offers magnificent opportunities for water activities (fishing and boating), mountain sports and variety of other activities such as hiking, yachting, ballooning hang-gliding, parasailing and abseiling. Places of interest include the aquarium, private zoo, Snake Park and a cableway. Hartbeespoort Dam has a number of arts, craft and curio outlets and it is part of the Heritage route to the World Heritage site (Cradle of Humankind) where a variety of historical and cultural interests are to be found (Platinumweekly, 2011).

However, the water used for these activities recreational, farming and fishing, is contaminated with cyanotoxins that are produced by cyanobacteria during the blooming and the decaying seasons, which affect the

quality of the businesses round the dam. Therefore users of this water with toxins are exposed to the health risks toxins (Mokoena et al., 2016). What is not known is how is the quality of water and other activities around this area affect the Hartbeespoort dam area economy.

RESEARCH PROBLEM

The Hartbeespoort dam water is highly contaminated by cyanobacteria toxins as results of nutrients such as phosphate and nitrogen from the northern side of Johannesburg. The Hartbeespoort dam population is increasing, however, the economically effect of contaminated and the reasons of the population increases in not well explained.

AIM AND OBJECTIVES

This study aim to determine the water quality and economically effects of Hartbeespoort dam areas. This was done by assessing the water quality from the sources used by the communities, and then by determine the challenges and benefits in costs of using Hartbeespoort dam water for irrigation and the business around the study area respectively.

METHODS

Study area and sample size

The study took place in the Hartbeespoort dam area which situated in the North-West province of South Africa. The residents of the Meerhof community use the Rand Water supply, and Refentse residents use tank water supplied from the Schoemansville water treatment plant. The residents of Kosmos and Zandfontein use both communal taps and tank supply from Schoemansville water treatment. Households were randomly selected from a cluster group of different settlements around the study area. The study population size was 504 and comprised members of 76 participating households, including Meerhof school pupils; 55 (11%) were <5 years old and 449 (89%) were >5 years old.

Study design

The study design was comprising the quantitative and the desk-top studies.

Quantitative data - Water sample collection

Water samples collected for the study were grouped according to the water-type used. Water samples were collected from the water containers of all participating households as well as from their respective water sources (e.g. communal taps, ground water, tankers and Rand Water), resulting in 183 samples. Water samples were collected between 2012 and 2013 during two seasons, which were the blooming (spring and summer) and decaying (autumn and winter) periods of the cyanobacteria. For households that did not store water, samples were collected from the nearest tap in their yard or kitchen. For communal-tap samples, the water was allowed to run at high pressure for few seconds before collection, and the bag was opened and filled with the water immediately to avoid contaminating the water. During sampling of the stored water containers, the household members were asked if the water had been treated with bleach (NaOCl) and if so, the time that they had treated the stored water. This was necessary in order to assess if the water treatment using bleach at the household level had been at least 30 min prior to sampling because this is the acceptable contact time between the toxins and the chlorine before consuming the water.

Microcystin analysis

After collection of the samples for microcystin analysis, two drops of Lugol's solution was added to each water sample, which was immediately placed in a black plastic bag to prevent exposure to sunlight (Mackie and He, 2005) and stored at 4°C in a cooler box. Upon arriving at the laboratory, 2 mℓ of each water sample was decanted into an Eppendorf tube and frozen at -80°C until further analysis of the toxins. Analyses for microcystins were performed with the Abraxis Microcystins-ADDA ELISA kit from Toxisolutions in South Africa, following the Abraxis

procedure (PN.520011) using six standard solutions and one control. After mixing, washing and incubating the microcystin solutions, the microtitre plate was placed into the micro-reader to determine the results.

Desk-top data - Economically data around Hartbeespoort Dam

Review data were search in the search engine such as google scholar, yahoo, Science direct using the following keywords: crop farming in Hartbeespoort dam, drinking water, recreational (fishing, swimming and boating), property development, tourism, natural conservation, and smell of cyanobacteria. From the literature review the articles that were not addressing the good and bad of the social-economic of Hartbeespoort dam were excluded. Total of 7790 articles were screened and only 20 articles considered for review in this study.

Statistical analysis

Data were captured using Microsoft Excel Office 2010, and statistical analyses were carried out using STATA 10. Then, data were analysed using percentage, and correlation statistics and the analysis of variance (ANOVA).

Ethical consideration

In all studies involving either human or animal activities, the ethical considerations become the most important factors to be considered in the study plan, and includes the participation of specialist personnel and type of laboratory to analyse the samples and specific materials to be used. The project was submitted to the Tshwane University of Technology (TUT) Ethics Committee and permission was obtained, ref: REC/2012/03/001

RESULTS

HARTBEESPOORT DAM WATER QUALITY

The Hartbeespoort Dam was primary developed for irrigation purposes, at which more than 80% of water is used for agricultural farming. Water from the Hartbeespoort Dam is also used for drinking by almost all people staying around the dam. The dam is eutrophication and the dominant species is *Microcystis Aerugenous* which produce microcystins. Microcystins were found in almost all the water samples collected from the following water sources, dam (4.3 & 5.0 µg/L), ground water (2,8 & 0.1 µg/L), communal taps (0.0 & 1.4 µg/L) and tank (3.5 & 0.5 µg/L) supplied water sources, in both the blooming and decaying seasons respectivily, used by the communities around study area. Most of the studies (Oberholster and Ashton 2008, Roux and Oelofse, 2010) proved that the water is highly contaminated by toxins producing cyanobacteria (Figure 1) that pose a serious challenges of using the water in this dam. Water from the sources still stored in the stored containers at the households level, this is because most of the water sources are not consistent supplying water to the communities. Small screw tops plastic containers of 20 and 25 L are used. The presence of toxins were found in water samples that were stored containers (Figure 2) at household level below the acceptable limit of 1 µg/L except containers Rand Water in decaying season was 1.5 µg/L.

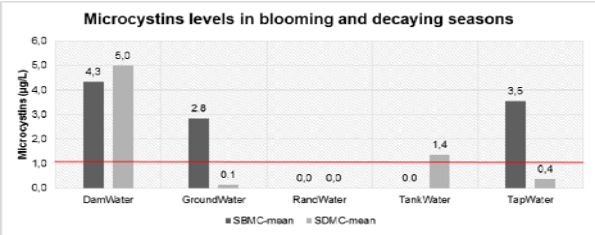

Figure 1: Microcystin data from water sources, grouped by seasons.
SBMC = sources blooming microcystin and
SDMC = sources decaying microcystin

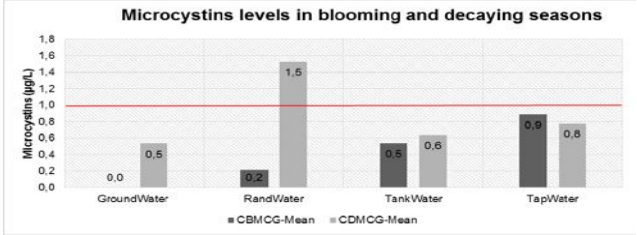

Figure 2: Microcystin data from water containers, grouped by seasons.
CBMCG = containers blooming microcystin and
CDMCG = containers decaying microcystin

The water treatment system is unable to treat enough water to supply the communities with enough water, as currently the Schoemensville water treatment systems treat at least 10 mega litre of water than what is expected which is 15 mega litre as per demand in the blooming seasons. Treated water was proven to have some Microcystins at the point-of-collection which mean water is still exposes people to some of the toxins (Mokoena et al., 2016). Although the piped water supplied from Hartbeespoort dam passes through formal water purification processes that includes filtration and disinfection, there is a risk of certain cyanobacteria related toxins as well as cryptosporidium passing through the treatment works, particularly during periods of high algal growth within the main reservoir. Furthermore residents living close to the irrigation canals and farm workers exposed to irrigation water, as well as recreational users of the dam itself, may be at risk of contracting water related diseases that are associated with microcystins. Toxins in drinking water lead to gastroenteritis, which lead people to use health facilities than usually, while those who can afford they buy their drinking water every day. More money is invested on water and health by the members around area. As saying prevention is better than cure, if more money can be invested in treating water for the community will prevent exposure to cancer promoting and gastroenteritis illness causing toxins Microcystins.

THE CHALLENGES AROUND HARTBEESPOORT DAM AREA.

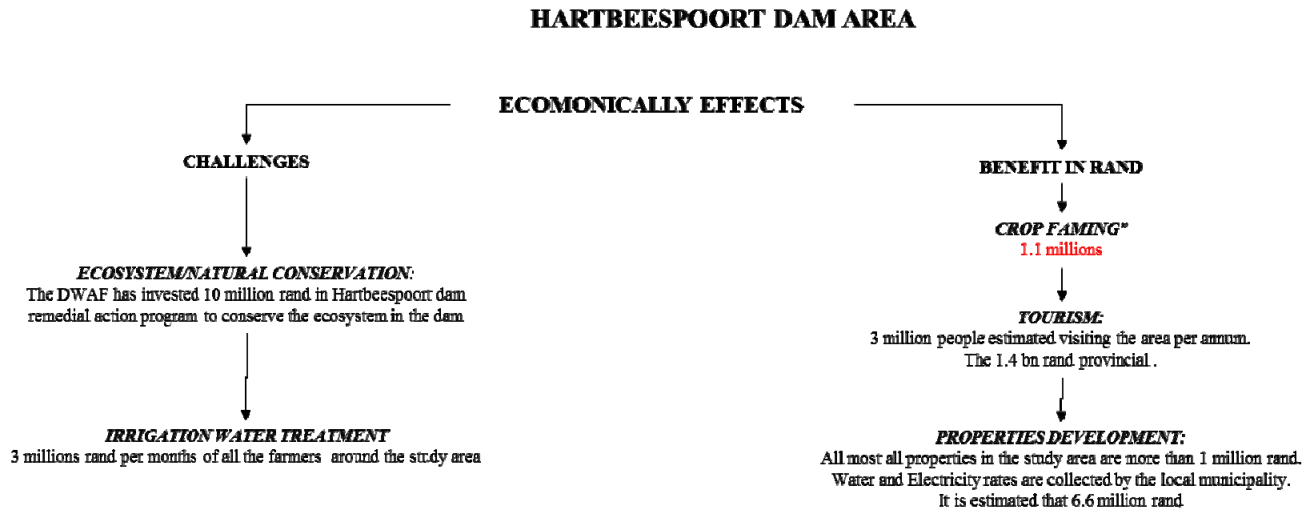

Figure 3: The Hartbeespoort dam economically challenges and benefit

ECOSYSTEM AND NATURAL CONSERVATION

The Hartbeespoort Dam water is one the dam that is highly contaminated by cyanobacteria. The presences of the cyanobacteria is the indication of the highly nutrients that the water body receive through its tributes. This high level of contamination affect the ecosystem such as dying of fish (Wesson, 2016). Some of the species in the dam are affected by the toxins and die off, however, harvested fish exposes toxins to human as they are contaminated. This fish are also in the food chain of either human, birds, or other big fish in the water (Figure 4). The contaminated water by cyanobacteria toxins is also used by human, wild and domestic animals for drinking purposes. Hartbeespoort Dam community members and South African government have introduce hyacinth plant in the dam in order to control the nutrients that are responsible of cyanobacteria blooming such as phosphate and nitrogen. The plant should be at least 15% on the dam on order to allow other activities such as boating and fishing should take place. The government programme which is Hartbeespoort Dam Remedial Action (Metse a me programme) is used to control the ecosystem of the Hartbeespoort dam. More than R10 millions to R900 million has been spent in rehabilitating the species and removing the hyacinth (Harding et al., 2004; Tempelhoff, 2012). Since the government stop funding the Metsi-a-me programme in 2016 the hyacinth had over-growing (van Huizen, 2017). The 30% of the dam is covered with hyacinth (Figure 5). This affect businesses such fishing, boating and other water activities from this dam.

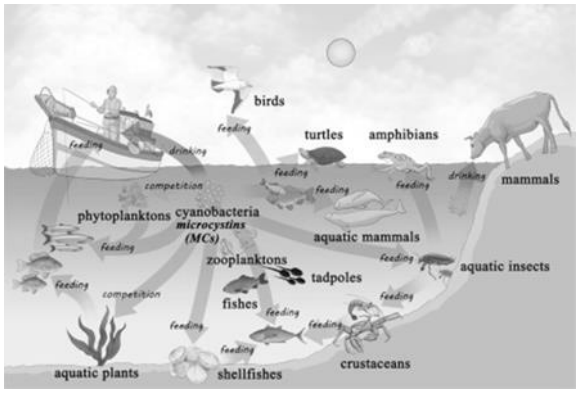

Figure 4: Cyanobacteria microcystin toxins contamination ecosystem cycle in the water (Source Chen et al, 2016)

Figure 5: Hyacinth plant over-growth in the Hartbeespoort Dam (Source: Author, 2017)

TREATING WATER FOR IRRIGATIONS

The Hartbeespoort dam water supply 130 square kilometre downstream water for irrigation schemes. Small and big farmers in the area are forced to use expensive water treatment process before using the water for irrigation. Some of people users reverse osmoses to treat water to irrigate their crops. The system itself is expensive both to buy and maintain. It was found that the farmers around the study area spend more than 3 million rand to use water for irrigation per months at Madibeng municipality (Madibengtime, 2015). Some of the big retailers had pull out their business with the farmers around Hartbeespoort Dam because health issues due to *Escherichia. Coli* and toxins from Hartbeespoort Dam water (Stuijt, 2012). It is demanding for the farm owners to treat Hartbeespoort Dam water for their seedling not to exposure them from the toxins. The effect of not treating their irrigation water is that retails does not buy crops as is contaminated by cyanotoxins. Irrigation water is used for irrigating crops as well as to wash fruit and vegetables when preparing batches for the fresh produce market.

ECONOMICALLY BENEFIT OF HARTBEESPOORT DAM AREA

Crops farming

Crop farming mainly maize and sunflowers should be the main revenue generator of the economy around the study area. However, the monthly generation were found to be 1.1 million less than 50% of the amount used to treat water for irrigation. This challenges have be found that is because of the less market demand of the products. Big business such as Woolworth's retailers has stop buying product because of the presence of *E. coli* and toxins in the crops (Stuijt, 2012).

Tourism

The Hartbeespoort Dam is one of the major tourism destination in North West province. There are different opportunities for tourists, such as recreational activities such as swimming, fishing and boating, mountains and South Africa history. It is estimated that the Hartbeespoort dam area receive 3 million visitors per annum, this tourism business was found to generate 1.4 billion annual in the province (Visser et al., 2002).

Property development

It was reported that more than 46% of property owners earn more than a million rand per annum (Long & Hoogendoorn 2013). Total of 26% owns their businesses. Most people have built their properties as their second homes. This is because that the area is successful developing and there are different opportunities such activities offered in Hartbeespoort dam, tourism, shopping centres and preserved South African history. Hartbeespoort dam and Brits areas are the two main areas that the Madibeng municipality receive revenue monthly. Therefore the Hartbeespoort dam area contribute 6.6 million rand annual to the municipality revenue. Recreation activities increases the demand of the accommodation. This has been seeing by increase of second home owners, guest and lodge houses builder (Long & Hoogendoorn, 2013). Houses near the show line of the dam are affected by the smell produced by the smell of dying cyanobacteria cells which smell like sewage (van Ginkel, 2011), however, this cannot affect the growth of the business such as property development.

CONCLUSION

The presence of cyanotoxins cyanobacteria in the Hartbeespoort dam has high economically effects of the agricultural business as it cost millions to the farmers, who are supposed to clean their water before watering their seedling. Hartbeespoort dam water which is contaminated by either toxins or other bacteria is used to clean the farming final products, this also become health concern for the retailers buying this farm produced. The water challenge livelihood is exposed to health risk from drinking, eating fish, crops irrigated by the water from the dam and tourism is challenged by the smell in decaying seasons. The tourism and property development due to accommodation demand as a results of the tourism and second home owner affect Hartbeespoort dam economy in a positive way.

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