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Non-point source pollution in China, policies and best management practices: Lessons for Uganda

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Non-Point Source Pollution (NPSP) is a serious environmental threat for water ecosystems in China. It is created primarily by overuse of agrochemicals. Uganda, which is still far behind in developing its agricultural, industrial and mining sectors, is facing the same problem. This paper looked at various policies in place to control NPSP in China and Uganda. Lessons for both countries, particularly Uganda, whose environment is not very polluted, have been drawn and the gaps highlighted for policy makers to address. Despite the commitment of the Chinese government in tackling this problem, NPSP is still a serious environmental problem. In conclusion, there is need for both countries to involve the public in NPSP awareness campaigns, and policy formulation and implementation. Where possible, collaboration between the two partner states should be enhanced.

INTRODUCTION

Non-Point Source Pollution (NPSP) is one of the major environmental threats affecting water quality in many countries [1,2]. In some parts of the world, it is not taken seriously and sometimes, it is given little focus and attention. Presently, the wash-out and runoff from agricultural lands contributes to the impairment of natural waters more than it did a few decades ago [3]. It is a serious challenge to water quality. Water quality deterioration is related to population growth, city expansion and other anthropogenic activities [4].China is one of the countries that has faced this environmental threat from overuse of agrochemicals [5].With a population of over 1.3 billion people, China is one of the leading users and exporters of fertilizers in the world [6,7]. These have helped the country to attain food security at the expense of the environment. With the recent adjustment in population policy, the country will need to produce more food, thus using more agrochemicals. For example, reports indicate that Nitrogen (N) fertilizer use is much higher than the required for optimal yield in China. In some cases, it is up to 600 kg N ha−1 [8].

Currently, Uganda's state of NPSP is not a big concern, but as the population increases, there will be an increasing need for food and economic development through the promotion of industries, mining and other activities to address food insecurity and unemployment, just like China has done for the last few decades. All these will greatly contribute to NPSP.

The main objectives of this paper are first to find out the gaps in policies that China is using to control NPSP; second, to draw lessons for Uganda from Chinese policy perspectives. China and Uganda are development partners and, as a result, are required to meet sustainable development goals without compromising the quality of the environment.

Justification

China and Uganda are endowed with a variety of water resources ranging from small to large watersheds. These have been affected by NPSP; the quality of water and soils in most regions of China has been more threatened and contaminated [9]. The need for food security and economic growth through agricultural intensification, industrial development, mining, and construction activities have all come at the expense of environment. All these anthropogenic activities have contributed to greenhouse gases and various pollutants, which affect water bodies [10] and enhance climate change. In addition, the huge demand for food in China has created resistance from farmers who are not willing to reduce Nitrogen (N) fertilizers in fields [11]. More than 2% of the lakes in China are extremely eutrophic [5]. NPSP affects the water quality of soil and water [12]. Also sediment loads of Phosphorus and Nitrogen in most river sub basins increase with climate change [13] thus requiring better policies and management of NPSP as well as adaptation strategies for climate change.

DISCUSSION

Perception about NPSP in Uganda and China

China has many environmental challenges and these have affected people in various ways. Most Chinese have little knowledge or awareness of NPSP [14]. This is also the same with their counterparts in Uganda. The few awareness campaigns by Non-Governmental Organizations (NGOs) do not specifically

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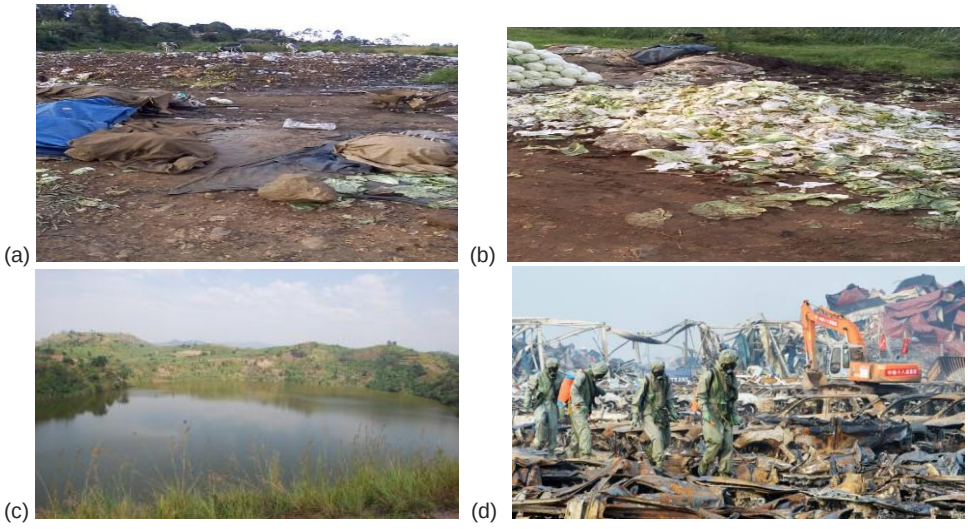

Figure 1 Poorly managed sites in Uganda and China

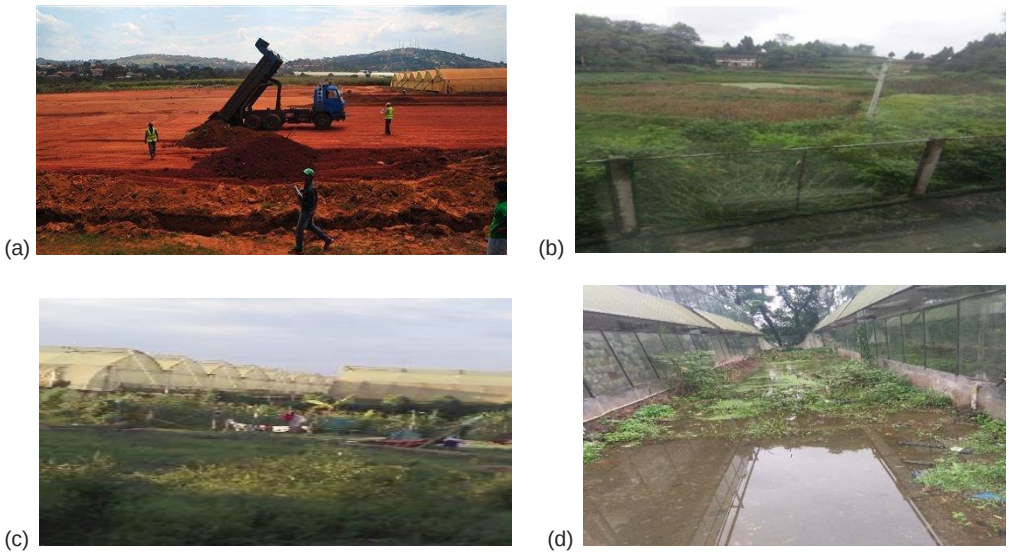

Figure 2 Destruction of wetland and river ecosystems in Uganda and China

target NPSP, but rather, just environmental issues as a whole. Furthermore, these NGOs are weak with many challenges, including funding [15]. This limits their impact and creates public mistrust. People rely on government to find solutions for environmental challenges [16] Understanding and awareness are determined by experience, age and education. Some farmers in China are aware of agricultural NPSP, although they have inadequate scientific knowledge about its management [17]. Understanding and perception of NPSP are vital. If the stakeholders have adequate knowledge, they can actively participate and demand action from leaders through the formulation of government policies. Generally, perception and environmental awareness of environmental issues in China need more momentum for the public to have a positive response [18]. This should be the same for Uganda to create vigorous citizen interest in issues relating to NPSP.

Factors influencing NPSP in China and Uganda

Farmers need high production: Most farmers have no access to agricultural extension services. They apply more agrochemicals, especially fertilizers, either knowingly or unknowingly because, they have been used to a practice of high fertilizer application rates since 1980s [19].

Inadequate Agricultural Extension Services to give guidance: This leaves farmers with no option but to use agrochemicals in an unsustainable way. Uganda's agricultural extension services are burdened with inadequate personnel. For example, an Agricultural Officer takes charge of over 5000 farmers (1:5000)

[20].China also has diverse challenges, including low efficiency in extension delivery; inadequate and poorly trained agricultural technicians and lack of appropriate extension system [21].

Low efficiency: This is because of overreliance on chemical fertilizers. The utilization rate is especially low in the rice growing regions of China [22].

Climate change: Although this is a global problem, some countries are more affected than others. Being a large country, China is affected by climate change differently. For example, N pollution in semi-arid regions is influenced by frequent and severe droughts and floods [23]. Floods carry a great deal of sediment from fields where agricultural practices are poor, and sweep through towns where wastes and poorly disposed garbage are all deposited in water bodies.

Soil erosion: China loses approximately 5.5 billion tons of soil annually [24]. The sediment carried from fields and forested areas contain N and P that contributes to the mineralization of water bodies. In Uganda, loss of soil due to soil erosion has resulted in migrations [25].

Policies: China's environmental protection policies began in 1973 and they have been reviewed several times [26].The country has enacted many policies, but the challenge is that they are top-bottom [27] with budget allocation constraints. There are many policies that relate to this problem, such as the fertilizer policy, that enable farmers to access fertilizers cheaply [28].Uganda's policies lack implementation and they are also top-bottom with little involvement by local stakeholders

Development of horticulture (vegetable and flower growing in China and Uganda, respectively): Intensive vegetable production, especially green house cultivation in the areas of Liaoning, Shandong and other areas, use fertilizers exceeding 200 kgN/ha, with the highest of 740 kg/ha. This has caused Nitrate pollution [29].

Aquaculture production has also generated a lot of chemical contaminants such as Lead (Pb) which have been detected in some water bodies [30].

Sources, activities that contribute to NPSP in China and Uganda

Poorly managed fields and sites: In most cases, these fields have not been prepared using good agricultural practices. As a result of the runoff, a lot of soil and nutrients are transported to water bodies.

Poorly managed abattoir (a) and a heap of garbage (b) on roadside agricultural market in Fort Portal, Uganda. In (c), Lake Kyema(Uganda) has had its water change from blue to brown due to human activities while (c) shows heaps of scattered e-waste in Guiyu province of China (Figure 1). Areas where mining is an economic activity, such as Anhui, Fujian, and Guangdong, are more polluted with Cadmium (Cd), Copper (Cu) and other heavy metals [31]. Areas near Kasese in Uganda have also been polluted with Cu heavy metals [32].

Roads and bridges: China has had massive infrastructural development of roads and bridges. All these generate huge runoff which contains pollutants. Destruction of fragile ecosystems that act as sinks have been damaged thus causes most pollutants to reach water bodies without interruption.

A bulldozer clears the wetland (a) for a flower farm near the shores of Lake Victoria, Uganda. In a fish pond was colonized by algal blooms in Pinchang County while (d) shows a poorly drained area of the greenhouse in Chongqing all in Southwest China (Figure 2). Livestock rearing areas are serious potential sources of NPSP due to N and P from such areas [33]. In some parts of Uganda, such as western and North East, livestock graze haphazardly (Table 1).

Although there are various kinds of policies regarding pollution and general environmental protection in two countries, they have not worked effectively and transparently to protect the environment. Some of those policies have been implemented with exclusion and bias because of corruption or political bias. A case in point is Amooti Nyakana versus National Environmental Management Authority (NEMA) in Uganda [34]. In this case, Nyakana's house was demolished because he had built it in a wetlands area. However, other people in the same country under the same laws were permitted to build in the wetlands.

The issue of environmental policies should not be left to a single country. Actions and policies in one country can affect ecosystem services and human well-being in another [35]. Policies can be assessed against three criteria: effectiveness, efficiency and appropriateness [36] and they become sustainable if they get the community support. Policies fail because of structural, implementation and scope issues [37].

Status of water quality and soil health in China and Uganda

In China, water is categorized into five major grades as shown in Figure 3. Water in China is of different classes with a big component not fit for human use or any human activity, not even for agricultural use, with a small component for human consumption. Most lakes in China fall into one of the above categories with the pollution resulting from organic substances, the main drivers of ecological change in ecosystems [38]. This results into cyanobacteria algal blooms which colonize water bodies as seen in Figure 2, b.

Soil health in China is a big concern because most soils are polluted by heavy metals, and some regions are lightly polluted [39].Others are so highly polluted that crops can absorb pollutants [40]. This affects food quality and safety. Heavy metal pollutants can cause many diseases, especially in children. This is common near the Yangtze River Region, which is famous for growing rice and fish farming. In this area, Cd and Cr are serious paddy rice pollutants [41]. Approximately 11% of digestive cancers are caused by chemical contaminants in drinking water [42].

In vegetable growing areas, the soils are heavily polluted with excess fertilizer and pesticides. In a survey, [43] found that 91% of the farms in China had accumulated N, P,Cd and Zn. Heavy metal pollutants as a result of solar greenhouses have been identified to be a serious problem in Bohai Bay, Jiangsu, Hebei and other areas [44,45]. Use of fertilizers also leads to salinity and soil acidity [46].

In Uganda, over 35% of the people lack easy access to safe water [47]. Women and children, especially in the dry areas of the North and Northeast, walk long distances in search of water. This situation has worsened due to drought caused by climate changes. Infrastructure underdevelopments, including inadequate treatment methods, are key bottlenecks to having access to clean

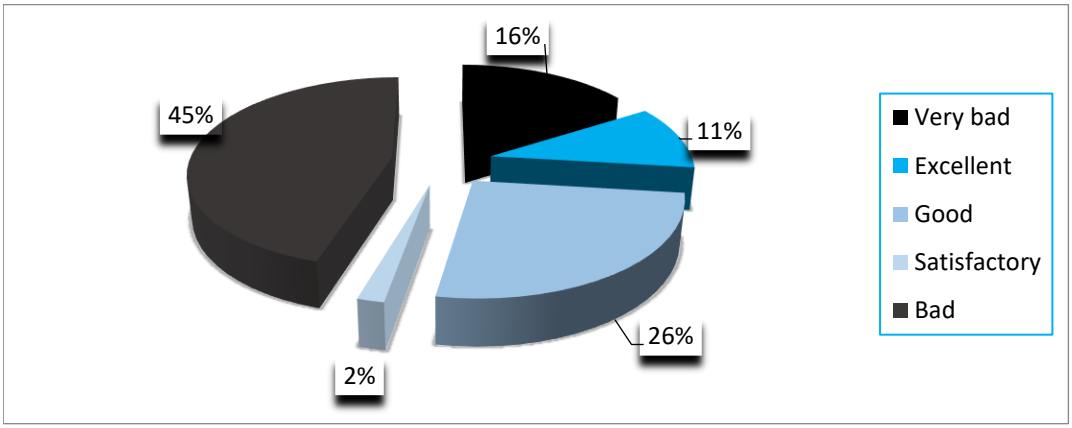

Figure 3 Ground water qualities in China
Source: Adjusted from MEP state of Environmental Report, 2014

Table 1 Key environmental policies to control NPSP in Uganda and China

Policy/plan	Department	Focus
Peoples Republic of China		
Pollution discharge permit system	State council	For industries with excesses in pollution discharge
Water Saving Action Plan	National Development and Reform Commission, Ministry of Water Resources, Ministry of Science an d Technology	Water-efficient irrigation, alternative resources.
Management Measure on Water Efficiency Labelling	National Development and Reform Commission, Ministry of Water Resources (MWR)	Water saving products produced domestically.
Opinions on Fully Promoting River Chief Mechanisms	State Council	River Chiefs will be appointed to take charge of river qualities.
Opinion on Deepening on Collaboration in the Greater Pearl River Delta Region	State Council	Pollution Prevention, drinking water supply and flood risks
Industrial Green Development Plan (2016-2020)	Ministry of Industry and Information Technology (MIIT)	Water use per unit of industry
Policies on Pollution Control Technologies of Thermal Power Plants	Ministry of Environmental Protection	Guidance on water recycling
Soil Pollution Prevention and Action Plan	State Council	
Guiding Opinions on Setting Strict Ecological Red Lines	State Council	All provinces and regions to establish ecological red lines by 2020
Implementation Plan on Environmental Impact Assessments Reform	Ministry of Environmental Protection	Resource Use Maximization
Environmental Protection Tax Law	National People's Congress	Change from resource fee to tax
Orderly Development of Coal-Fired Power Generation	National Development and Reform Commission, National Energy Administration	Strictly control plants
Guiding Opinions on Establishing a Green Finance System	Ministry of Finance, Ministry of Environmental Protection (MEP)	Water rights and pollution permit trading market

Notice on further controlling planning and construction of coal fired plants	National Energy Administration (NEA)	Postpone some approved projects
13Five Year Plan (FYP) on Sea Water Utilization	National Development and Reform Commission, State Oceanic Administration (SOA)	Daily desalination capacity of up from 1m to 2.2mt
Notice on promotion of public-Private partnership in Public Services	Ministry of Finance	
Improve Compensation Mechanisms for Ecological Protection	State Council	Cover all key ecosystems and important regions by 2020
13FYP on Ecological Environmental protection	State Council	Strictly control key polluting industries.
13 FYP on Energy Saving and Pollution Reduction	State Council	Promote sustainable energy and reinforces coal consumption reduction.
Policies on Pollution Control Technologies of Thermal Power Plants	MEP	Guidance on water recycling
The Republic of Uganda		
The National Wetlands Policy	Directorate of Environmental Affairs (DEA)	Protect wetlands
Energy policy	Ministry of Energy and Mineral Development	Energy resources
National Fertilizer Policy	Ministry of Agriculture, Animal Industry and Fisheries (MAAIF)	Improve market structure, quality, and low priced fertilizer.
Water policy	Ministry of Water and Environment (MWE)	Promoting measures to control water pollution
Some international protocols		
The Stockholm convention on Persistent Organic Pollutants (POPS)	China and Uganda are signatory to this convention that eliminates and restricts production of; Pesticides: aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex	Human health and the environment from chemicals that remains intact in the environment.
Convention on Wetlands 1971	China and Uganda are signatories. An international treaty for the conservation and sustainable use of wetlands	Environmental pollution
Basel Convention on Control of Tran boundary-movement of Hazardous Wastes and their disposal 1989	China and Uganda are signatories Wastes regulated include; Used oils, used lead acid batteries POPs.	Human health and environment against adverse effects which may result from trans-boundary movement and management of hazardous wastes.

Source: Authors

Table 2 Suggested approaches to reduce on NPSP in China and Uganda

Theme	Approach
Good Agricultural Practices (GAPs) and Best Management Practices (BMP). Water from paddy rice fields should never be channeled to the rivers or lakes. Recycling the water and nutrients back to the field. Control soil erosion	Most big rivers should be fenced off to keep animals and people out of riparian area. Use of no tilling equipment near the river channel. Plan for irrigation recycling of water and nutrients from paddy fields and other big agricultural enterprises. Limit unnecessary access to small and big watersheds Open areas on land should be filled up and planted with trees and grass Use of terraces, tree planting and other mechanical measures

Research and funding	Increase budget for research and innovation not only to universities but also for private partnerships and companies, create think tank platforms.
Collaboration between governments	This should be among natural resource managers and other actors to advance knowledge about NPSP.
Strengthen Environmental courts	China has over 100 special environmental courts but Uganda has none.
Stakeholders	In most cases, environmental problems are legislated upon and discussed from up to the bottom. This approach must change and incorporate everybody in protection of environment. Where possible, communities must be rewarded for engagement in pollution control.
Engineering, technological and sustainable approaches on; a) Big agricultural project b) Roads c) Ships d) Urban runoff e) Buildings f) Garages	Work out the system that leads fertilizers from rice fields to recirculate water to paddy fields just like in hydroponic systems. The water that leaves roads, buildings and other known point sources during runoff should not flow direct to the streams or rivers but instead channeled to a separate area for treatment.
Registration of farmers and the resource they have at their disposal	This will enable extension of agricultural services easily, monitor the application rates of fertilizers, water usage and general good agricultural practices that control soil and water pollution.
Identification and monitoring of possible sources of NPSP.	All possible sources of pollutants need to be identified including those pose a future danger to the lives of people and general environment
Develop policies and laws for; a) Water for agriculture b) Water for industry c) Water for domestic use d) Reserve water e) Water for treatment	Allocate amount of water for each sector and have strict policies on use, contamination and treatment. Enhance inspection and improve technologies for water use, allocation and clean up. The reserve water should be kept clean and controlled by all means
Punishments, fines and closure	The offenders of environment need to be dealt with strictly and uncompromisingly.

Source: Authors

water in parts of the country with high level of Nitrate, Phosphorus and fecal coliforms [48].

Water pollution in Uganda is as a result of many factors which include rapid urbanization, creation of slums and urban farming. All of these contribute to NPSP. In general, there is pollution of lakes and rivers as a result of increased human activities characterized by eutrophication [49]. Other practices, such as wetland degradation (Figure 2a & b) and poor waste disposal have also contributed to NPSP.

Stakeholders 'involvement in policy formulation

The key stakeholders in planning and management of NPSP should be the people at all levels. That is the general perception of what the standard should be. Unfortunately, in most developing countries, the key stakeholders are not aware of this role. This is because of inadequate information and awareness as well as a lack of confidence and trust in government systems. Policies that regulate pollution are made by the government on behalf of the people and the participation of local communities is less common [50]. National law does not allow NGOs to have active participation in carrying out mass awareness campaigns about soil and water pollution. In Uganda, however, stakeholders such as NGOs may participate easily in awareness campaigns about general environmental issues, especially those relating to water [51].

Suggested measures to control NPSP in both countries

The control measures of Non-Point source pollution can be divided under the following themes (Table 2).

Lessons for Uganda basing on Chinese perspective

Uganda's environment is still relatively undamaged despite cases of contamination and pollution in some watersheds. Learning from both the positive and negative aspects of Chinese policy can be useful to strengthen policies, GAPS, BMP and court structures to protect the environment and deliver environmental justice to those who violate the law. There is need to plant trees and grasses along the rivers and lakes or any other water bodies to stop sediments from reaching the water. The formulation, implementation and supervision of policies and laws regarding NPSP should include all the stakeholders and communities.

Uganda needs to invest appropriate resources in developing agro-ecological based agricultural practices to co-exist with developing industrial and mining sectors. Currently, Uganda has no environmental courts to investigate environmental crimes and hold those responsible for those crimes accountable. Such special courts could speed up justice and give advice to policy makers to tackle gaps that might exist in the laws. Uganda and China need to work out a robust plan of training and equipping agriculture and environmental extension personnel that can advise farmers and the public on how to sustainably use natural resources. The current extension network copes with many challenges. There is need to register all farmers and other people whose activities seriously jeopardize the stability of environment. This will make monitoring, advising and resource allocation easier. Such a plan can assist government to access information through a database more readily.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Although there are many policies and laws in both China and Uganda, they do not specifically target NPSP. They target different types of environmental pollution and in so doing, reduce NPSP. In addition, the policy formulation and implementation process does not fully involve all the stakeholders who are the custodians of environmental resources. The information and awareness process about NPSP is limited, and government partners such as NGOs whose role would be to complement government initiatives are not active due to the political landscape particularly in China that does not support activism. The government of the People's Republic of China is committed to tackling NPSP. This is seen in the many policies that have been formulated and reviewed over time to time to cope with the environmental problems. However, the water and soil conditions are still bad and need further commitment in terms of resources, technological innovations as well as public involvement, including non-state actors like NGOs. There is a great need for both countries to involve the masses in awareness campaigns, policy formulation and implementation.

Recommendations

Uganda needs to tighten its laws and policies on NPSP and to ensure there is strict adherence because NPSP effects take long time to be reversed. The two countries need to strategize and make policies that can protect water resources, encourage agricultural planning and management, and ensure all resources are sustainably exploited. The state entities bodies in both countries responsible for pollution control are so numerous that the allocation of funds and responsibility as well as supervision of the government ministries and affiliated agencies can be difficult. There is need to streamline and harmonize the activities of ministries and agencies in one primary ministry. These can be staffed, equipped and facilitated with enough resources.

MATERIALS AND METHODS

Search strategy

This study relied on a systematic search of articles, reports and other literature from secondary data published in different journals. Articles which were relevant to NPSP in China and Uganda focusing on pollution of water, ecosystems, soils, and effects of pesticides, fertilizer utilization in China, Uganda, NPSP and policies were selected for this review. We considered relevant articles published in English and dated from 2010. All papers that fell short of these criteria were excluded. The terms used in the search strategy were non-point source pollution, fertilizer and pesticide use, ecosystem degradation, eutrophication, soil and water pollution. A total of 140 articles were retrieved from various databases. After selection based on the above criteria, 51papers were chosen and the following themes developed:

a) Perception about NPSP
b) Sources of NPSP
c) Environmental policies
d) Factors influencing NPSP
e) Water quality
f) Stakeholders' involvement
g) Lessons for Uganda basing on China's perspective

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Conflict of interest

No conflict of interest has been declared

Authors' contributions

Mr. Natamba Leo is the author and the brain behind the article right from the conception of the idea
Prof. Zhang Weihua. Read through the work and gave constructive comments
Prof. Shiqiang Wei advised us to use figures and included more technical terms. He also gave constructive comments for revision
Prof. Jinshong Zhang provided some useful articles that suit the article and gave positive criticisms that led to fine tuning the work
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