

# Heavy metal pollution and transboundary issues in ASEAN countries

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## Abstract

The presence of heavy metals in waterways is a major threat to human health, and such metals cause stomach cancer and brain damage. There is a growing trend towards heavy metal pollution in the Association of Southeast Asian Nations (ASEAN) countries due to inappropriate environmental management and the development of the region's chemical industry. In some border areas, transboundary heavy metal pollution significantly affects people's daily lives. The traditional ASEAN approach to solving heavy metal pollution has limitations due to various problems that affect the ASEAN region, such as unbalanced economic growth, a shortage of environmental technology, and a lack of regional law enforcement. As a result, more effective regional governance on heavy metal pollution and transboundary issues is urgently required. In this paper, network governance theory is used to study environmental problems. This paper recommends that voluntary governance is used to supplement traditional state-centric governance.

*Keywords:* Environmental management; Heavy metals; Network governance; Pollutions; State-centric governance; Voluntary governance

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## 1. Introduction

Heavy metals in waterways are detrimental to the environment and can affect river ecologies, fish migration, agriculture, and human health (Tchounwou *et al.*, 2012). Heavy metal pollution has affected ASEAN in recent years because many ASEAN countries have developed chemical and mining industries that produce wastewater containing heavy metals. The wastewater being directly released into waterways without suitable treatment directly threatens human health and causes cancer (McGee & Greenberg, 1992; Graeme & Pollack, 1998). Around 30,000 people in the ASEAN area suffer from heavy metal pollution every year (Graeme & Pollack, 1998; World Health Organization, 2010), and the fishery industry has also been affected by heavy metal pollution (Sowana *et al.*, 2011). Direct economic losses due to heavy metal pollution are estimated to be as high as 1.5 million United States dollars

doi: 10.2166/wp.2019.003

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(USD) per year in ASEAN countries (Owlad *et al.*, 2009). Some pollution occurs on national borders, creating transboundary issues (Hart *et al.*, 2001). For example, according to a technical paper produced by the Mekong River Commission (MRC), transboundary pollutants from the Khorat Plateau in Thailand directly affect Pakse in Laos (Edwin *et al.*, 2007).

Consequentially, it is essential that ASEAN countries work together to tackle heavy metal pollution and transboundary issues. Currently, four countries (Cambodia, Laos, Thailand, and Vietnam) in the lower Mekong basin are members of the MRC, an organisation that monitors water quality. However, many ASEAN countries do not have effective policies regarding heavy metal pollution. Some ASEAN countries are also reluctant to respond to transboundary heavy metal pollution, as they do not want to interfere in each other's internal issues. The current ASEAN approach (including that of the MRC) cannot reduce heavy metal concentration effectively regarding water treatment. In this paper, network governance theory will be used to analyse environmental problems. This paper proposes that traditional state-centric governance is gradually supplemented by voluntary governance, a move that may help to solve environmental pollution problem in some areas.

## 2. Heavy metal pollution and transboundary issues in ASEAN countries

Heavy metals are generally defined as metals that have high densities and cause water contamination and environmental problems. Heavy metals in the natural environment mainly include cobalt, nickel, arsenic, cadmium, chromium, copper, iron, mercury, manganese, lead, and zinc (Hawkes, 1997). One major source of heavy metals in ASEAN countries was chemical and mining factories. Without proper wastewater treatment during chemical and mining processes, heavy metals will be released into waterways, and people who drink water that contains a high concentration of heavy metals will suffer from cancer and brain damage (Graeme & Pollack, 1998; Owlad *et al.*, 2009). Such environmental problems are common in many developing countries in Asia, such as China and India. However, due to recent economic growth, ASEAN countries are increasingly witnessing heavy metal pollution (Hart *et al.*, 2001). Nguyen *et al.* (2016) studied pollution and found that heavy metal concentrations had reached serious levels in the Red River (see Figure 1) in Vietnam. Berg *et al.* (2001) found an average arsenic concentration of 159 µg/L in the Red River, which exceeded the World Health Organization's (WHO's) provisional guideline value of 10 µg/L. Cheevaporn and Menasveta reported that high concentrations of heavy metals (arsenic, cadmium, chromium, copper, iron, mercury, manganese, lead, and zinc) had directly led to habitat degradation in the Gulf of Thailand. The authors stated in a paper that heavy metal problems would become more severe if preventive measures were not taken promptly (Cheevaporn & Menasveta, 2003). The research mentioned above clearly reflects the serious impact that heavy metal pollution has on ASEAN countries.

In some cases, chemical or mining companies near national borders have released wastewater that has not been properly treated, leading to transboundary issues. Transboundary issues may lead to further environmental deterioration because (1) the source of pollution is sometimes in one country and the victims in another, and (2) environmental law enforcement is much more difficult. This paper examines heavy metal pollution and transboundary issues in the Mekong River (a large river that passes through Myanmar, Laos, Thailand, Cambodia, and Vietnam; Figure 1). Yunnan Key Laboratory for International Rivers and Transboundary Ecology Security reported that the release of heavy metals (chromium, lead, nickel, and zinc) from Myanmar in the upper Mekong might directly affect water

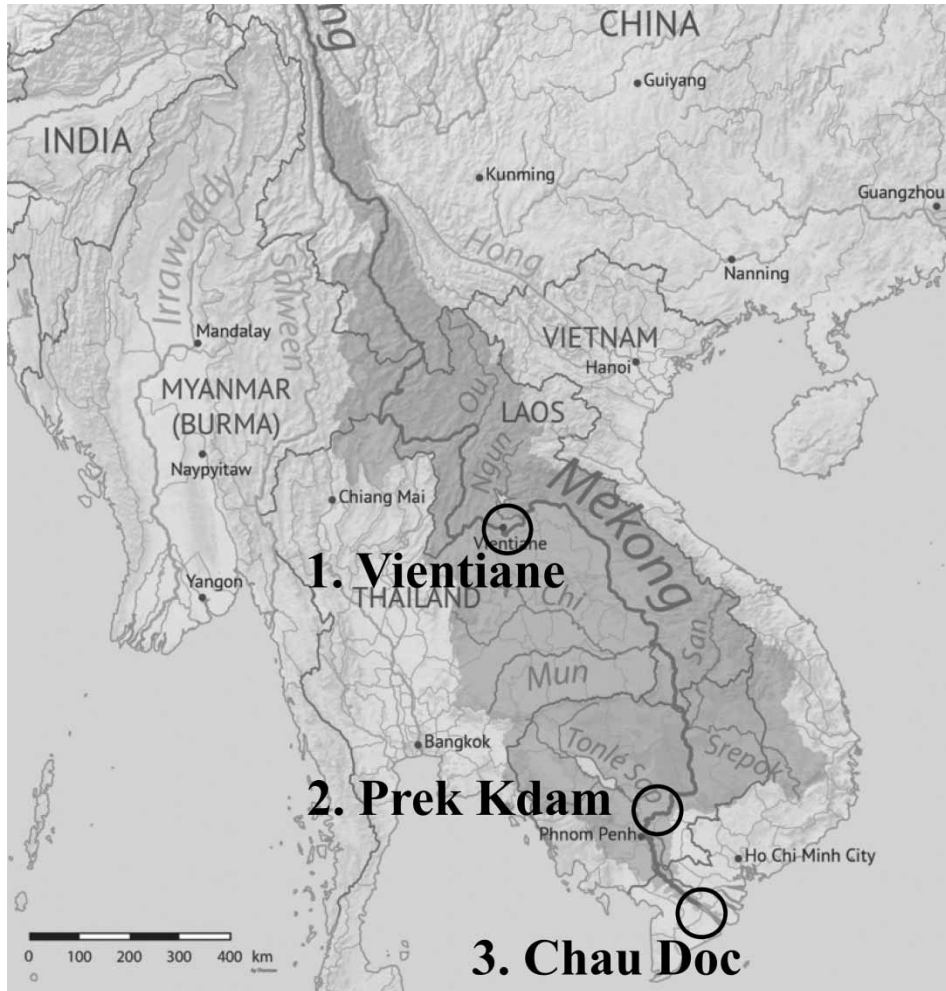


Fig. 1. A schematic illustration of the Mekong River and three sample points (Vientiane in Laos, Prek Kdam in Cambodia, and Chau Doc in Vietnam). The figure is copied from Natural Earth (with permission) and has been replotted by the author.

quality in Laos, Vietnam, Thailand, and Cambodia in the lower Mekong basin (Fu *et al.*, 2012). A technical report released by the MRC stated that the concentration of arsenic was high (Table 1) in the upstream of the Mekong River, which had the potential to negatively affect the ecology of the area and human health in the downstream of the Mekong River (Hart *et al.*, 2001). The concentration of mercury was high at one sample point (Prek Kdam, Cambodia), but the mercury had not been detected at the other two sample points (Table 1). Different heavy metals could have different behaviours (higher mobility versus lower mobility) that might cause various transboundary issues.

The main causes of heavy metal problems and transboundary issues in ASEAN countries (Hart *et al.*, 2001; Fu *et al.*, 2012) are:

1. Limited wastewater treatment techniques
2. Weak environmental education system

Table 1. Heavy metal pollution in the Mekong River.

Stations/countries	Arsenic (mg/kg)	Mercury (mg/kg)
Vientiane (upstream), Laos	15	Below detection limit <sup>a</sup>
Prek Kdam (midstream), Cambodia	14	0.26
Chau Doc (downstream), Vietnam	11	Below detection limit <sup>a</sup>
Threshold effect concentration <sup>b</sup>	10	0.18
Impact on human health	Confirmed carcinogen	Acrodynia, Hunter-Russell syndrome
Impact on ecology	Poorly drained soils	Fish poisoning, Minamata disease

<sup>a</sup>Below detection limit (BDL), suggesting no contamination detected at the sample point.

<sup>b</sup>Threshold effect concentration (TEC): the concentration of contaminants in the waterways should be below the TEC, meaning toxic effects are unlikely to occur. The data were obtained from Technical Paper No. 15, MRC (Edwin *et al.*, 2007).

3. Little public awareness of environmental protection
4. Insufficient environmental inspections
5. Inefficient communication between countries
6. Lack of regional environmental legislation.

Considering the rapid development of the chemical and mining industries in ASEAN countries, the environmental situation may deteriorate further in the next 10 years, and problems involving transboundary water pollution may become more serious. Solutions to such environmental problems are strongly needed. Current approaches and efforts towards solving transboundary water pollution will now be analysed and discussed.

### 3. ASEAN's current approach

ASEAN's current approach to problem-solving, known as 'the ASEAN way', is in line with the traditional culture of Southeast Asia. Key elements of the ASEAN way are consultation, consensus, and non-interference. Member countries communicate and move forward on issues without affecting each other's sovereignty.

According to the blueprint of the ASEAN way, the countries set up the Mekong Committee to jointly address water issues (Mehtonen *et al.*, 2008). The MRC was established (with four members: Laos, Thailand, Cambodia, and Vietnam) in 1995. One of the goals of the MRC was to improve water quality and control transboundary water pollution. With this aim in mind, the member countries decided to set up a standard to be used when monitoring water quality in the Mekong River and organise a meeting and discuss potential research collaborations annually.

Although this report has played a positive role in mitigating environmental problems, it has many limitations: (1) the report does not cover details of pollution problems, e.g. governance models and environmental funding; (2) the report does not promote communication between different organisations, e.g. research institutes, but is important for the advancement of environmental technology and policy; (3) regional laws to control transboundary water pollution have not been established and enforced; and (4) the report is not given enough public attention.

After examining the weaknesses of the current ASEAN approach and the MRC, this paper will analyse environmental problems using network governance theory and look for possible new approaches to transboundary issues.

#### 4. Network governance theory to water pollution

Network governance theory involves the creation of synergy between various competencies and sources of knowledge to deal with complicated problems (Jones *et al.*, 1997). Network governance can be applied to study the ecological, social, and political challenges involved in environmental issues. Due to the complexity of both the heavy metal problem and transboundary issues, scientists, practitioners, and policymakers use network governance to evaluate environmental policy and also to help people to understand individual roles within a network (Bixler *et al.*, 2016). Network governance is used to increase the efficiency, or reduce the agency, of different organisations as the efficiency can be improved through distributed knowledge acquisition and decentralised problem-solving, and the effectiveness can be enhanced by the emergence of collective solutions to regional problems in different self-regulated organisations (Poole, 2014).

In traditional theory, there are four classic modes of governance: (1) state-centric (hierarchical) governance, (2) multi-partner governance, (3) market governance, and (4) voluntary governance (self-governance) (Lowndes & Skelcher, 1998). Nowadays, ASEAN countries use traditional state-centric governance to solve most environmental problems (Figure 2). In brief, after a pollution event occurs, a research institute will report the problem to the government. To deal with the problem, the government will design a new policy and implement it. In this process, non-governmental organisations (NGOs) play the role of advocate/assistant to state government. Business associations might also invest/provide funding for some environmental projects. Finally, the environmental problem is solved.

It was clear that the state government played a central role in the traditional state-centric governance (Figure 2). However, in recent years, the limitations of traditional state-centric governance in regard to heavy metal pollution and transboundary issues in ASEAN countries have been revealed:

1. Reaction times are too long. If there is an acute case of water pollution, e.g. a chemical factory has illegally released wastewater, a research institute may need to spend several weeks investigating the

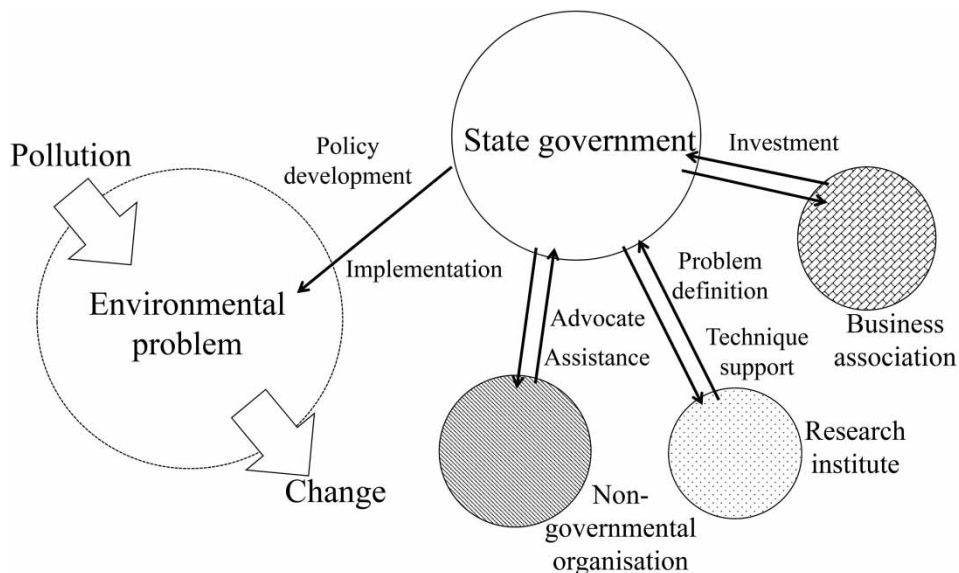


Fig. 2. A schematic illustration of current state-centric (hierarchical) governance and an environmental problem.

situation. When the issue is reported to state government, it will take several more weeks to adjust relevant policies and deal with the problem. Yet, water pollution can negatively affect people’s lives in just a few days.

2. Pollution control is often inadequate. Some pollutants appear in waterways suddenly, yet research institutions may be unable to create suitable treatment plans due to technological limitations.
3. The state-centric governance model lacks good communication between different organisations. Especially in border areas, the source of pollution is sometimes in one country while the victims are from another. Countries often need to communicate in order to understand pollution issues and implement environmental protection policies. But when communication is only made at a state level, it is clearly inefficient.

The aforementioned problems are not independent. They interact with one other and, eventually, lead to greater environmental pollution. Due to the limitations of state-centric governance, this paper proposes that voluntary governance supplements state-centric governance (see Figure 3). This new model of governance will lead to more efficient treatment of environmental pollution in ASEAN countries.

Voluntary governance is a concept that applies to different scales of organisations in order to improve the efficiency through decentralisation. Voluntary governance describes a system where organisations can exercise all necessary functions of power without interference from state government (Przeworski, 2009). Figure 3 shows a schematic illustration of voluntary governance and state-centric governance systems in ASEAN countries. The main differences are: (1) the connections in the voluntary governance system are tighter, (2) the organisations in the voluntary governance system are better connected to other countries, (3) the organisations in the voluntary governance system can connect and communicate

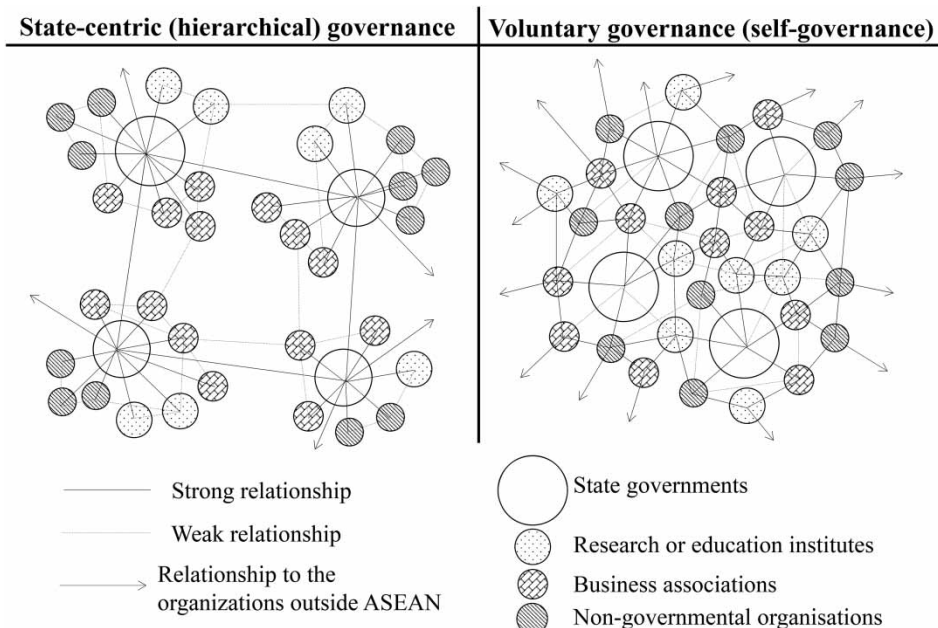


Fig. 3. Modes of network governance in ASEAN countries.

more effectively while only state governments communicate actively under state-centric governance, and (4) voluntary governance is more of a horizontal network whereas state-centric governance is more of a vertical management network. As a result, voluntary governance is able to utilise peer pressure to encourage network members to act. This results in several advantages. The ASEAN countries can mobilise all organisations effectively and respond more quickly to pollution events. At the same time, voluntary governance can promote communications between organisations and improve the relations among ASEAN countries. Due to such benefits, this paper suggests that voluntary governance should supplement the traditional state-centric governance system in the context of environmental concerns in ASEAN countries.

To demonstrate the benefits of voluntary governance, this paper offers a relatively straightforward example: the development of research into environmental techniques and policy at the National University of Laos. The National University of Laos is located in Vientiane, and its Faculty of Environmental Sciences is one of the best research institutions in the country. Vientiane is a city that is located on the upper Mekong and is affected by heavy metal pollution. Vientiane is also located in a national border area. Events that affect the city can cause transboundary issues involving Thailand and Laos (Figure 1). To tackle such issues, Laos needed to conduct environmental research. The number of Laotian publications related to this field of study will be used to measure the success of such research.

Ten years ago, the Laos government mainly used traditional state-centric governance in the environmental field (Fujita & Phanvilay, 2008; Yayoi & Kaisone, 2008). State-centric governance meant that the government provided funding and evaluated professors. However, progress was slow. Government officials were not always environmental experts, and it was difficult for them to evaluate professors' research papers and contributions quickly and accurately.

Over the last 10 years, the Laos government transitioned from state-centric governance to voluntary governance (Fujita & Phanvilay, 2008; Yayoi & Kaisone, 2008). Voluntary governance meant that the government provided funding to professors working in environmental research, but professors were evaluated in a peer-review system. Professors needed to receive high scores from their peers rather than the state government. Under the new system, professors strengthened their regional and international cooperation because they were required to know each other well and get the recognition. In this process, the professors developed novel ideas and improved their research quality. Important technical improvements were made, including the use of novel techniques, such as *in situ* X-ray, to quantify heavy metals (Tsushima *et al.*, 2015) and the invention of automatic water quality monitoring systems based on dissolved oxygen (Chounlamany *et al.*, 2018). Simultaneously, important researches focused on environmental policy were conducted. One project focused on managing the local people and communities that relied on the Laotian mining industry, which produces large amounts of heavy metal (Lahiri-Dutt *et al.*, 2014). Another important research is to adjust the policy to make use of rainwater to clean the pollution sites (Noda *et al.*, 2017). Such papers clearly reflect the improvement in environmental research in Laos. From 2005 to 2019, there has been a threefold increase in the number of publications and highly cited papers produced by the National University of Laos (see Figure 4). The research and education system in Laos are significantly improved (Knight, 2015). Furthermore, enhanced international and regional communication has helped to solve transboundary water pollution issues (Cash *et al.*, 2003).

The improvement of research performance illustrates the limitations of state-centric governance and the advantages of voluntary governance in specific environmental scenarios. This improvement also can

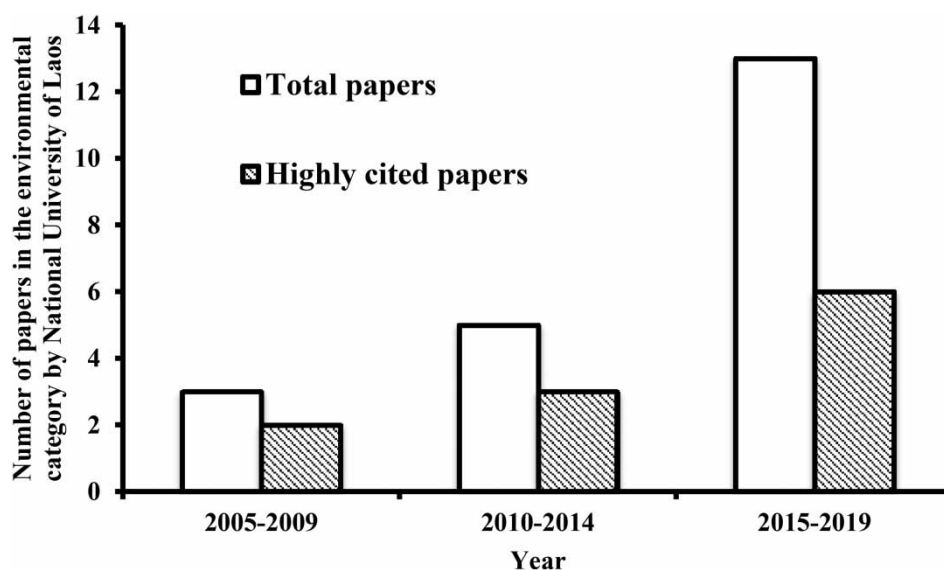


Fig. 4. The number of papers in the environmental category published by the National University of Laos in Science Citation Index (SCI). Highly cited papers are defined as papers with more than five citations in all periods. Data source: Microsoft Academic Graph ([academic.microsoft.com](http://academic.microsoft.com)).

be found in other organisations (e.g., NGOs and local government) in some ASEAN countries. This paper recommends that the ASEAN countries rely more on voluntary governance, peer pressure, and collaboration between organisations in order to solve transboundary issues and eliminate heavy metal pollution efficiently (Table 2).

Table 2. Summary of state-centric governance and voluntary governance.

	State-centric (hierarchical) governance	Voluntary governance (self-governance)
Basis of governing	Authority and regulation	Peer pressure
Policy instruments	Sanctions; Tax incentives; Propaganda	Codes of conduct
Advantages	Traditional governance; Formal process	Efficient and novel governance; Fast reaction; High flexibility and efficiency; Enhanced communication; Strong motivation
Limitations	Slow reaction; Low flexibility and efficiency; Little communication between organisations; Inadequate pollution control	Difficult implementation; External problem; Limited resource
References	(Lowndes & Skelcher, 1998; Fujita & Phanvilay, 2008; Yayoi & Kaisone, 2008)	(Jones <i>et al.</i> , 1997; Lowndes & Skelcher, 1998)



## 5. Limitations of voluntary governance

Although this paper discusses the positive aspects of voluntary governance, voluntary governance still has many challenges (Elinor, 2010). When facing future heavy metal pollution and transboundary environmental problems in ASEAN countries, voluntary governance might face some limitations:

1. The implementation of voluntary governance is challenging. ASEAN countries are accustomed to a culture of acquiescence to authority, although authorities are sometimes not experts in a particular field. Changing peoples' habits and ideas is a long process that requires the efforts of various organisations. In particular, senior ASEAN leaders need to be determined to decentralise power in the environmental sector. They need to believe that giving power to environmental experts will lead to significant improvements.
2. External problems exist. For example, Chinese companies operating in the upper Mekong produce heavy metal pollution that can affect water quality in the entire river (Fu *et al.*, 2012). The Chinese government also sells waste to many ASEAN countries, which contains a considerable quantity of heavy metals that pollute the water (Shinkuma & Nguyen Thi Minh, 2009). Such external problems have directly led to the deterioration of the environment in ASEAN countries, and the solution is not just in the hands of ASEAN countries.
3. Gathering resources are challenging. To transform from traditional static-centric governance to voluntary governance, leaders need to raise a variety of resources, including funding, management techniques, and human resources. Although the process will be difficult at the beginning, outstanding ASEAN leaders have the ability to achieve the accumulation of original resources and ultimately achieve a win–win situation for economic development and environmental protection through the voluntary governance.
4. Obstacles remain in regard to communication between countries and organisations, even within the context of voluntary governance. For historical reasons, ASEAN countries and organisations often use different languages and have different ideas. There are also huge differences between the cultures of individual countries and organisations. Communication barriers that negatively affect the promotion of voluntary governance exist. Encouraging people to communicate in the same language and to produce similar ideas requires long-term effort.

This paper points out that the promotion of voluntary governance can, in some areas, solve specific problems regarding heavy metals and transboundary issues in ASEAN. However, due to various limitations, voluntary governance cannot be the only solution for all problems. Other methods need to be adopted together to tackle environmental issues.

## 6. Conclusions

This paper has discussed heavy metal pollution and transboundary environmental issues in ASEAN countries. Many ASEAN countries (Laos, Cambodia, Thailand, and Vietnam) have suffered from the effects of heavy metal pollution. Such environmental problems might have been made worse by the rapid growth of the chemical industry and flawed environmental inspections.

Many ASEAN countries use traditional state-centric governance to manage the environment. However, state-centric governance is sometimes inefficient because it cannot mobilise every organisation.

This leads to (1) longer response times for environmental issues, (2) inadequate control of heavy metal pollution, and (3) limited communication that is mainly on a governmental level regarding transboundary pollution issues. Such factors can, eventually, lead to governance failures and the growth of environmental pollution.

This paper has discussed the possibility of replacing state-centric governance with voluntary governance in an environmental context. This change has already been effective in some areas, such as in Laos, where the National University of Laos has strengthened research regarding environmental techniques and policy. Voluntary governance could be promoted more widely in other ASEAN countries or developing countries in other areas.

Finally, this paper has also discussed the limitations of a voluntary governance model. Although voluntary governance might be highly efficient, significant limitations remain (challenging implementation, difficult communication, external influence, and scarce resources), and it cannot solve all environmental problems. More governance methods should be used to deal with heavy metal problems and transboundary issues.

## Acknowledgements

The author thanks the School of Geography and the Environment, University of Oxford, and the elective course leaders of ASEAN environments for their support in the manuscript preparation process.

## Conflict of interest

There are no conflicts to declare.

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Received 6 January 2019; accepted in revised form 17 June 2019. Available online 31 July 2019