Applied Ergonomics 57 (2016) 80–93

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

River and fish pollution in Malaysia: A green ergonomics perspective

Wai Ching Poon [a, *], Gamini Herath [a], Ashutosh Sarker [a], Tadayoshi Masuda [b], Ryohei Kada [c]

[a] Department of Economics, School of Business, Monash University Malaysia, Jalan Lagoon Selatan, 46150 Bandar Sunway, Selangor, Malaysia
[b] Agricultural Economics, Policy & Agribusiness, Department of Agricultural Science, Faculty of Agriculture, Kinki University, 3327-204 Naka-machi, Nara 631-8505, Japan
[c] Shijonawate Gakuen University, 5 Chome-11-10 Hojo, Daito, Osaka Prefecture 574-0011, Japan

ARTICLE INFO

Article history:
Received 22 February 2015
Received in revised form
21 January 2016
Accepted 7 February 2016
Available online 22 February 2016

Keywords:
Green ergonomics
Human factors
Heavy metal pollution
Sustainable development

ABSTRACT

Human activities, such as industrial, agricultural, and domestic pursuits, discharge effluents into riverine ecological systems that contains aquatic resources, such as fish, which are also used by humans. We conducted case studies in Malaysia to investigate the impacts of these human activities on water and fish resources, as well as on human well-being from an ergonomics perspective. This research shows that a green ergonomics approach can provide us with useful insights into sustainable relationships between humans and ecology in facilitating human well-being in consideration of the overall performance of the social-ecological system. Heavy metal concentrations contained in the effluents pollute river water and contaminate fish, eventually creating significant health risks and economic costs for residents, including the polluters. The study suggests a number of policy interventions to change human behavior and achieve greater collaboration between various levels of government, academia, civil society, and businesses to help establish sustainable relationships between humans and ecology in Malaysia.

1. Introduction

Ergonomics (or human factors) deals with the study of relationships between humans and other elements of a system they interact with in a workplace and applies relevant theories, principles, data and methods to optimize the performance of the system while maximizing human well-being (IEA, 2015). The ergonomics discipline primarily emerged to address challenges with relationships between humans and the machines/equipment they operate and interact with in a workplace. Several scholars have attempted over the past three decades to broaden the discipline's narrow scope to accommodate natural and ecological environment by exploring designs for optimizing relationships between humans that degrade the natural environment (or ecology) and the natural environment that in turn reduces human well-being. As a part of this effort, new concepts such as “green ergonomics” (Hanson, 2010, 2013; Thatcher, 2013) and “ergoecology” (García-Acosta et al., 2014) have been developed.

It is in this broader context of ergonomics that we examine how humans in the agriculture, industry and household sectors generate pollutants that move beyond the boundaries of their workplaces and degrade river water quality and fish health, causing a deterioration in the overall human well-being in Malaysia. In this regard, we conducted case studies to examine the impacts of human activities on river water and fish resources, as well as possible impacts of these phenomena on human well-being. We collected and analyzed water and fish samples from two rivers in Malaysia, the Langat and Klang rivers, and interviewed residents living in the river basin areas. Our findings reveal that heavy metals, such as mercury and arsenic, enter into the river water and contaminate water and fish, posing significant health risks and economic costs for residents, which in turn disrupts the performance of the social-ecological system. A green ergonomics approach can help explain sustainable relationships between humans and ecology in facilitating human well-being in terms of the performance of the social-ecological system performance.

2. Human-nature considerations in ergonomics

Given that the scope of ergonomics was confined to the relationships between humans and equipment in a workplace, Moray

* Corresponding author.
E-mail addresses: poon.wai.ching@monash.edu (W.C. Poon), gamini.herath@monash.edu (G. Herath), asarker@yahoo.com (A. Sarker), tad.masuda@gmail.com (T. Masuda), kada0113@gmail.com (R. Kada).

http://dx.doi.org/10.1016/j.apergo.2016.02.009
0003-6870/

(1993) has emphasized the potential of ergonomics to include issues of water and food shortages, inefficient energy usage, pollution and waste. Furthermore, Moray (1995) argued that the role of ergonomics "is to design a lifestyle support system that elicits the behavior required to reduce the severity of the global problems." Helander (1997) was more specific and stated that ergonomists should address "global environmental and social problems, such as the pollution of the big cities." Sauer et al. (2004), arguing along similar lines, noted that ergonomics should focus on pro-environmental considerations, which are becoming increasingly important in recent years in various parts of the world.

Zink (2006) proposed the human factors and ergonomics (HFE) approach to sustainable development, requiring a complex balance between economic, social, and natural capital. Additionally, Steimle and Zink (2006) argued that with reference to sustainable development, HFE needs to focus on both social and environmental capital. From the social perspective, Docherty et al. (2002) earlier argued that sustainable initiatives are those that are within the physical, physiological, and psychological limits of human functioning that allow adequate rejuvenation opportunities (i.e., recreation and rest).

Adopting the perspective of human-nature connections, Hanson (2010) used the term "green ergonomics" to focus specifically on how ergonomics can assist in reducing environmental impact by considering production methods that use less energy. Drawing on Hanson's work (2010; 2013), Thatcher (2013) further redefined the term as the reciprocal interdependent relationship of human and natural systems, pushing the traditional boundary of ergonomics to accommodate environmental concerns. This includes human interactions with the environment causing pollution of natural resources and corresponding consequences for the environment, conservation, and sustainable development (see also García-Acosta et al., 2014; Haslam and Waterson, 2013; Lange-Morales et al., 2014; Pilczuk and Barefield, 2014; Radjiyev et al., 2015; Saravia-Pinilla et al., 2016; Thatcher et al., 2013).

The degradation of the natural environment can increase the incidence of cancers, respiratory problems and birth defects. Ergonomics interventions have focused on economics (eco-efficiency and socio-efficiency) and social factors (socio-efficiency and socio-effectiveness) but have largely ignored the impact on natural systems (Thatcher, 2013). The emerging green ergonomics promotes the understanding of the role of human-nature connections in meeting the goals of ergonomics. Humans are inextricably connected to the natural system (natural capital) and strains on that system can have significant negative implications for human health, safety, efficiency and effectiveness which ergonomics attempts to optimize (Pimentel et al., 2007).

Lange-Morales et al. (2014) have proposed the inclusion of sustainable development in ergonomics and human factors discipline. Following Thatcher and Yeow (2015), sustainability refers to not only sustaining human development, but also interactively sustaining the ecosphere that supports human habitation. Sustainable development and human factors embody a complex balancing of economic capital, social capital and natural capital, called the Triple Bottom Line (TBL) approach (Dyllick and Hockerts, 2002). The need for balance between these three forms of capital is guided by the assumption that poverty exacerbates negative environmental effects through over-exploitation of scarce resources (e.g. overgrazing, overirrigation, deforestation, poor agricultural methods, the use of outdated industrial machinery and polluting limited water supplies).

3. The research context

This work focuses on an ergonomic evaluation of heavy metal pollution in rivers of Malaysia. Water pollution has been of major importance in Malaysia as it affects the quality of river water (Department of Statistics, 2013). According to the Department of the Environment (2010), Malaysian industry produced a total of 1.88 million metric tons (MT) of scheduled waste in 2010, compared with 1.71 million MT in 2009. Human factors, including industrial practices, contaminate river water, exposing other people to metals such as arsenic, chromium, mercury, lead, and cadmium, which are extremely toxic in high concentrations. These metals can enter the food chain, affecting safety and public health and the well-being of society (Sany et al., 2013; Mokhtar et al., 2011). These effects can undermine the ecosystem values of rivers.

This research investigates how human activities cause pollution in river water. Specifically, this study aims to (i) identify heavy metal pollution in the Langat River and the Klang River in Malaysia, (ii) identify the human activities causing and exacerbating the effects of pollution, (iii) establish health impacts of polluted water in rural areas in Malaysia, and (iv) identify policy interventions to address human factors in order to reduce and mitigate ergonomic effects of pollution.

This research is important to Malaysia because a degraded riverine environment cannot provide the resources needed to promote health and well-being. The relationship between green ergonomics and river pollution has not yet been properly investigated in the country. The Malaysian government has not included heavy metal content in river water as a parameter in the Malaysian water quality index (Department of Statistics Malaysia, 2013). Further, Malaysia's capacity for and research on HFE is limited. The green ergonomics approach to examine river pollution and human factors in Malaysia is a novel extension of the ergonomics literature.

The contribution of this study is three-fold. First, this study provides insights on the usefulness of the HFE framework to understand river pollution and the implications for the future. Second, this study extends and adds to the repertoire of ergonomic studies in Malaysia. Third, while most studies of water and air pollution in Malaysia have been carried out in the immediate vicinity of the industries, industrial water pollution may have impacts far away from the immediate location of the industry. In order to adequately explain river pollution, a comprehensive understanding of the physical, economic, political, institutional and social dimensions is essential.

4. Human activity, sustainable development, and ergonomics: a framework

Ergonomics focuses on wellness at work and contributes to an understanding of employment practices, design of sustainability-oriented products, and more efficient work systems to ensure the safe operation of complex systems (Steimle and Zink, 2006). Human activities and river systems are embedded in complex socio-ecological systems (SES) with multiple subsystems. Interventions include designing eco-efficient systems and ensuring system health, safety, and socio-efficiency, as well as the usability of systems by people in a socially effective manner (Thatcher, 2013). In particular, there has been little focus on interventions that support eco-effectiveness and sufficiency. Steimle and Zink (2006) and Zink et al. (2008) called for a balance between the three dimensions of sustainable development. Dekker et al. (2013) argued that sustainability needs to embrace complexity and emergence in resolving HFE problems, and Thatcher and Yeow (2015) further argued that a shift of paradigm that moves from a local context (i.e., the linear model) to a larger variety of distributed systems is needed to support a more sustainable future.

The integration of sustainability with ergonomics occurred slowly (see Hendrick, 1996). McDonough and Braungart (2002)