

A Perception-Response-Evaluation (PRAVE)  
framework for societal-physical-based risk  
decision-making: A case of endocrine  
disrupting surfactants contamination in  
Vietnam

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## 論文内容の要旨

Endocrine disrupting contamination has been recognized to be a serious problem in modern societies over the last two decades. Nonylphenol and nonylphenol ethoxylates, known to have endocrine disrupting effects, have been used as surfactants in numerous industries, such as cleansing, textile, personal care products, pesticides, paper, and plastic. The chemicals are released into the environment mainly in form of domestic sewage and industrial effluent discharge. Recent studies have reported alarming levels of nonylphenol in the urban watercourses across Vietnam, which raises concerns about the ecological and health risk linked to endocrine disrupting surfactants (EDSs). Whilst a risk management framework for endocrine disrupting chemicals is lacking in Vietnam, and current risk management schemes merely rely on technical (or physical) risk assessments, this dissertation postulates an EDSs risk decision-making framework based on the integration of societal and physical perspectives (PRAVE framework). The research goal was operationalized in four studies that employed both types of qualitative and quantitative approaches.

Study 1 examined societal perspectives and self-protective behavior towards EDSs. Data was collected via a questionnaire survey and analyzed by structural equation modelling. Study 2 proposed an integrated modelling framework for evaluating non-carcinogenic health risks from nonylphenol contaminated food consumption. This was achieved by using ecological models which outputs were subjected to an exposure and risk evaluation. Study 3 proposed a firm behavior model based on a qualitative analysis of the Vietnamese textile firm's response to the need of nonylphenol and nonylphenol ethoxylates restriction. Study 4 assessed the distribution and removal of nonylphenol ethoxylates and nonylphenol from textile wastewater, where a cotton and a synthetic fiber factory were investigated and compared.

The first main findings were that: 1) the public judgments of EDSs risk were uncertainty-laden; 2) the patterns of risk perception and self-protection between pregnant women and young mothers and the remaining people were not significantly different; 3) perceived EDSs risk had no effect on the public habit of riverine fish consumption, whilst it was demonstrated that consuming EDS contaminated riverine foods posed a health risk to a large proportion of population; 4) the frequency of consuming EDS contaminated riverine foods was a key factor linked with health risk. This suggests immediate actions in order to tackle EDSs risk in urban cities. Accordingly, a social policy for raising awareness of EDCs risk amongst the public with a focus on pregnant women and young mothers is needed. To do so, building capacity for communicating and managing EDSs risk amongst governmental and non-governmental institutions, as well as conducting a comprehensive EDSs risk assessment covering a wide range of food and drink is essential. Since the EDSs contamination in Hochiminh city's canals has been found to have negative impact on the river in the adjacent province, the moral and legal responsibilities of the "polluter" towards the "sufferer" should be recognized in the legal system of environmental protection of Vietnam. Secondly, the study revealed that foreign regulations on EDSs restriction are able to impact positively the environment through changing the EDSs consumption and discharge behavior amongst the textile firms. Therefore, the roles of intermediary industrial/trade organizations in offering support to private textile firms in the form of useful information (e.g., regulatory and market changes, exporting requirements, technological and chemical innovations) are highlighted. Thirdly, there is a potency of continuing use and discharge of EDSs into the environment amongst the domestic textile firms, whereas

only well-designed and controlled coagulation-activated sludge processes can yield promising EDSs removal for textile wastewater. Hence, assessing the available wastewater treatment facilities of potential industries with regards to EDSs removal is needed, particularly focusing on those discharging directly into the environment. Additionally, integrating NP/NPEOs into the current standards for sewage and industrial effluent discharge and for surface water is recommended, whilst long-term strategies should aim to restrict the use of EDSs in manufacturing industries and products.

EDCs risk management in Vietnam could be kick-started by applying PRAVE framework which allows to design comprehensive strategies by mediating scientific and societal perspectives. The decision-making process could be supported by sub-models of ecological-health risk evaluation, risk perception-behavior, and firm's perception-behavior. Additionally, guidelines for dietary advice regarding riverine food product consumption and for assessment of wastewater treatment facilities regarding EDSs removal could be derived. The four studies in this dissertation, each contributes knowledge of one sphere of EDSs risk management, together have demonstrated the value and utility of PRAVE framework originally postulated by this dissertation.