氏　　名	BOURAGBA SAADIA
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論文審査委員	主査　准教授　駒井　克昭 教　授　早川　博 教　授　渡邊　康玄 准教授　吉川　泰弘 教　授　南　尚嗣

学位論文内容の要旨

In recent several decades, using of numerical computational models is getting more popular by planners, managers, engineers and scientists in different fields. Therefore, the assessment based on numerical computational models in water quality management seems promising.

The industrial activities have been caused severe damage to water ecosystems over time. The intensive industrial activities in urban area caused a significant increase in the quantities of hazardous materials, being released into rivers during wastewater disposal. The heavy metals are among the most prominent and danger pollutants resulting by the industrial activities. The monitoring of these pollutants in riverine systems is one of the most important water management challenges, because of their toxicity and their potential to accumulate and persist in the environment. Several studies related to the water quality modeling have been demonstrated the effectiveness of the hydrological models as powerful tools in prediction of heavy metal fate and transport in riverine systems.

The main objective of this thesis is evaluation methodology on heavy metals transport and pollution with the help of a distributed hydrological model (DHM), for environment management in urban river basins in developing countries. The thesis addresses the evaluation of the effectiveness of Geophysical Flow Circulation (Geo-CIRC) model based on Object Oriented Design (OOD) in modeling of multiple heavy metals transport in Harrach River in Algeria which is severely polluted with various heavy metals originating from industrial activities, in order to use as a helpful monitoring tool in water quality management of rivers. As well, a simple approach for varied partition coefficient (Kd) modeling was proposed in order to enhance and increase the model accuracy for simulation of heavy metals concentrations in river sediments.

The results showed that the Geo-CIRC model was able to simulate simultaneously the transport of multiple heavy metals in a river and present a comprehensive description of river contamination with only a minimal amount of observational data, where the application of OOD increased the model's effectiveness, by improving the model's flexibility even many unknown point sources exist, and supported the inclusion of multiple heavy metals in the simulation with reasonable accuracy. Likewise, the proposed empirical multivariate regression model was useful in estimation of the potential variables of the partition coefficient with physicochemical properties changes, as well introducing these changes in simulation increased the result accuracy of the model.

Including of Geo-CIRC model in monitoring strategy can provide comprehensive assessment of the environmental state in the river systems with less cost in short time by using less effort because of the OOD's advantage. Likewise, the model feature allows us to be able to simultaneously utilize much information which could be taken from limited monitoring data. As well, the proposed partition coefficient model can enforce the availability of sediment data.

論文審査結果の要旨

本論文は開発途上国の都市河川流域における環境管理のための分布型流出モデルを利用した重金属の輸送と汚染状況のアセスメント手法について研究を行ったものである。脆弱な環境管理の下で産業活動に起因する様々な重金属汚染が進んだアルジェリアのハラッシュ川を対象として、オブジェクト指向設計（OOD）に基づく物理モデル（Geo-CIRC）の有効性が評価され、従来の手法では難しかった未知の汚染源が多数存在する開発途上国の流域での重金属汚染の解析に成功した。同時に、河川堆積物中の重金属濃度のシミュレーションのモデル精度を向上させるための分配係数モデルが開発された。Geo-CIRCはOODの適用によりモデルの拡張性が高く、複数の重金属の輸送を同時にシミュレート可能にし、独自の評価アルゴリズムにより最小限の観測データで開発途上国特有の河川汚染を包括的に再現し、汚染源とその影響範囲を解析する手法が提案された。さらに、都市河川での生活排水由来の有機汚濁を考慮した分配係数モデルを開発し、シミュレーションの精度向上に寄与することが示された。最後に、これらの解析手法に基づいてOODの利点を生かした低コスト・高効率な環境モニタリング戦略策定に有益なアセスメント手法が提案された。

これらの研究成果は、開発途上国の都市河川における重金属汚染対策の学術的基礎として極めて重要であり、同分野における今後の新しい展開に貢献するものである。以上のことから、申請者は博士（工学）の学位を授与される資格があると認める。