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An analytical model for non-conservative pollutants mixing in the surf zone

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ABSTRACT

Accurate simulation of the surf zone is a prerequisite to improve beach management as well as to understand the fundamentals of fate and transport of contaminants. In the present study, a diagnostic model modified from a classic solute model is provided to illuminate non-conservative pollutants behavior in the surf zone. To readily understand controlling processes in the surf zone, a new dimensionless quantity is employed with index of kappa number (K, a ratio of inactivation rate to transport rate of microbial pollutant in the surf zone), which was then evaluated under different environmental frames during a week simulation period. The sensitivity analysis showed that hydrodynamics and concentration gradients in the surf zone mostly depend on n (number of rip currents), indicating that n should be carefully adjusted in the model. The simulation results reveal, furthermore, that large deviation typically occurs in the daytime, signifying inactivation of fecal indicator bacteria is the main process to control surf zone water quality during the day. Overall, the analytical model shows a good agreement between predicted and synthetic data ($R^2 = 0.51$ and 0.67 for FC and ENT, respectively) for the simulated period, amplifying its potential use in the surf zone modelling. It is recommended that when the dimensionless index is much larger than 0.5, the present modified model can predict better than the conventional model, but if index is smaller than 0.5, the conventional model is more efficient with respect to time and cost.

Key words | analytical model, fate and transport, fecal indicator bacteria, non-conservative pollutants, rip currents, surf zone model

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NOMENCLATURE

g	gravitational constant [9.8 m/s^2]
H	wave height [m]
k	first-order inactivation rate constant [hr^{-1}]
K	kappa number
m	sensitivity parameter
n	number of rip cells
Q	discharge rate [m^3/hr]
R	dilution ratio
S	beach slope
V	volume of the system [m^3]
v_{LH}	Longuet-Higgins longshore velocity [m/hr]
X	fecal indicator bacteria concentration, [MPN/100 mL]
y	longshore distance [m]
Y	rip cell spacing [m]
α	angle of wave approach to the shoreline
β	angle of beach slope
Subscripts	
l	longshore
o	influent
p	predicted concentration
r	rip current
s	synthetic concentration
Superscript	
t	time step

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