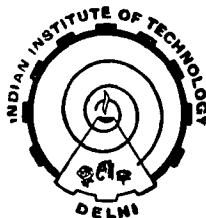


**SOME EXPERIMENTAL AND THEORETICAL STUDIES RELATED
TO THE TRANSPORT OF CARBON DIOXIDE IN THE
CIRCULATORY SYSTEM IN SIMULATED
DEEP SEA ENVIRONMENT**

By
INDU SUD

Thesis Submitted to the
Indian Institute of Technology, Delhi
for the award of the degree of
DOCTOR OF PHILOSOPHY



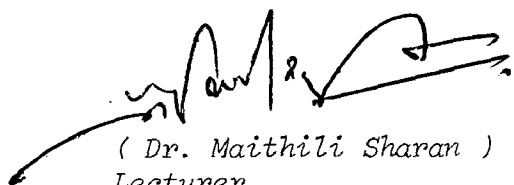
**Centre for Atmospheric and Fluids Sciences
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January, 1986**

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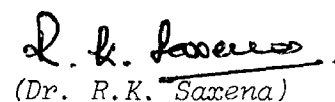
my parents and my daughter

CERTIFICATE

This is to certify that the thesis entitled "SOME EXPERIMENTAL AND THEORETICAL STUDIES RELATED TO THE TRANSPORT OF CARBON-DIOXIDE IN THE CIRCULATORY SYSTEM IN SIMULATED DEEP SEA ENVIRONMENT", being submitted by INDU SUD for the award of the degree of DOCTOR OF PHILOSOPHY, is a record of the original bonafide research work carried out by her. She has worked under our joint guidance and supervision and has fulfilled the requirements for the submission of this thesis. The results presented in this thesis have not been submitted in part or full to any other University or Institute for award of any degree/diploma.



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ABSTRACT

The impact of physical facts of submergence leads to various biological peculiarities which limit man's performance in underwater environment. Chief among these factors is the hydrostatic pressure which causes an increase in the respiratory gases dissolved in the blood and tissues. The increased gases can exert toxic effects on the human system.

Experimental studies have been done to examine the role of CO₂ under simulated hyperbaric environment. The hematological changes - the red blood cell numbers, the hemoglobin content, erythrocytic sedimentation rate and the hematocrit have been studied by exposing rats to ten atmospheric pressure for one hour. It has been found that there was a decrease in these parameters after exposure to pressure. A measure of the osmotic fragility of the RBC showed an increase, making the cells more liable to breakage. Also, rheological changes in the animals exposed to high pressures have been studied. The viscosity of whole blood and plasma increased after exposure to 10 atmospheric pressure. These studies have been done in vivo as well as in vitro and the results have been compared. Aseptic bone necrosis in these animals has been studied radiologically as well as histologically. Further, pulmonary

surfactant has been measured to see the effect of excess oxygen and its role in the accumulation of CO_2 has been discussed. The possible cause of a decrease in the surfactant has been determined by counting the alveolar macrophages. Histological examination of the lung have also been done. The influence of the changes in these parameters, studied experimentally, on the transport of O_2 and CO_2 in the circulatory system has been analyzed.

A mathematical model is proposed to deal with the simultaneous transport of O_2 and CO_2 in the systemic capillaries and its surrounding tissues. The model takes into account the transport of the species due to radial diffusion, convection, and the facilitated diffusion. The metabolic activity in the tissue is incorporated. Krogh tissue cylinder has been used as a geometrical representation of the capillary-tissue system. The resulting system of governing equations together with the physiologically relevant boundary conditions is solved numerically by the four-point semi-implicit scheme. A fixed point iterative technique is used to deal with the non-linearities in the model. It has been found that the concentration of oxygen and carbondioxide in the capillary and tissue increases as the diver goes deeper in the sea. The most vulnerable part from the point of view of toxicity of CO_2 has been determined.

Further, the effect of axial diffusion in the capillary and tissue is incorporated and the role of hemoglobin in the transport of O_2 and CO_2 has been accounted through linear functions, to simulate the conditions of hyperbaric environment. An analytical solution of the resulting system of elliptic partial differential equations with the physiologically relevant boundary conditions is obtained in closed form by the method of eigen-function expansion. Although the role of hemoglobin has been linearised in the model, its nonlinear effects have been taken into account indirectly. The degree of accumulation of O_2 and CO_2 in the capillary-tissue system has been studied. The physiological implications of these results in hyperbaric environment have been examined in the light of our experimental study.

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