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Image Processing Technique for Oil Spill Dispersion

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Abstract—*Containment of oil spills is important for extraction of oil from water and for maintaining the issues of safety of the environment. A number of advanced response mechanisms are available for controlling oil spills and minimizing their impact on human health and the environment. One of the important techniques is to use absorbent to arrest dispersion of oil in water. However, the efficacy of use of absorbent to arrest the dispersion and comparison of the performances of different absorbents in spatial dispersion is not an easy task. It is required to evolve a technique to identify the oil spill and its detailed dispersion with time. A chronological image based technique is suggested as the possible solution to the challenge of micro characterization of oil spills.*

In this research it was tried to adopt a technique for oil spill detection and its migration using image processing based technique. An experiment was conducted in a controlled environment, keeping the water surface static initially, and dropping the oil on it. A series of images were captured from a unique static platform over time. The photographs taken were in line with the speed of dispersion and were registered in the same coordinate system. The registered images were then classified to extract pixels occupied with oil. These were then processed further to determine clusters of oil, their spatial orientations and relative change with time. The performance gave clear and interesting idea to characterize the dispersion of spill of oil on water. The technique developed will be applied over complex cases of non- stationary water, multiple spilling of oil, in the presence of absorbents of different types.

1. INTRODUCTION

Oil spill can occur at offshore drilling, accidents of tankers or during transportation. It leads to spread of oil on water surface contaminating the environment [2], which causes serious health and safety issues. When oil mixes with water, it stays on the surface, forming oil-slick. The oil particles primarily move by advection and diffusion. Concentration gradient of oil and prevailing wave and wind actions control the dispersion of oil on the surface of water. The turbulence in the medium can lead to oil-in water or water-in oil emulsion in a few days after the spill takes place for the first time. Various techniques are available for restricting the spread of oil in water. The selection of equipment and or material to control the spill depends on nature of oil, the wave, wind or turbulence existing in the medium. Booms, barriers, skimmers are the widely used mechanical containment and recovery equipments for oil. Natural and synthetic sorbent materials are used individually or with other mechanical containment devices to control the dispersion [1-9]. Some time chemical and biological agents are used as dispersing, gelling agent to prevent dispersion and help in recovery for sensitive areas such as shorelines. Wide use of sorbent materials [6] in oil containment draws attention to the character of these materials and the need of understanding their efficacies in restricting the movement of oil. Sorbents are insoluble in nature, they swell up and help to retain oil by absorption and or adsorption. Their hydrophobic and oleophilic properties help to retain oil with them. Straw, hay, sawdust, etc. are considered natural and organic solvents which can increase 3 to 15 times in weight. Clay, sand, glasswool etc. on the other hand, are considered the natural sorbents which increase 4 to 20 times in weight. Many organic sorbents are loose particles and are difficult to collect after they are spread on the water. These problems can be counterbalanced by adding flotation devices. Plastic, polyethylene, polyurethane, rubbery materials, etc. are synthetic materials and can swell as much as 70 times of their weight to adsorb or absorb a large amount of oil from water surface. The rate of absorption, adsorption, oil retention, ease of application, etc. differentiates one Sorbent to another. It is not clear from the different approaches used to prevent oil spill or restrict them, how effective they are, i.e, percentage absorption, the duration it takes to absorb the oil or prevent spreading of oil, whether the material used should be spread on the surface, quantity of material to be used, requirement of exposure/duration of exposure, impact of such material vis a vis that of nature of oil, influence of current on material to be used, or can a naturally available cheap material be used at bigger/denser quantity on surface to work as oil spill preventer. Further, what method to be applied to determine the efficacy are not clear. The challenge demands developing a technique to closely observe the spatial changes taking place at the surface of water due to the movement of oil. To detect dispersion of oil with time, a close range photography with processing of images is considered an interesting option

2. MATERIALS AND METHODS

An indoor experimental setup was considered which can contain water and oil. Initially it was considered that experiment will try to simulate very still water condition in nature. Oil was dropped on the water surface. The movement or migration of oil was observed at short intervals from close distance using a camera. A circular container of about 50 cm diameter and 15 cm depth was selected for the study. A Sony 7.1 megapixel camera was mounted rigidly on a stable platform, centrally within 1 m from the water surface. A 50:50 mixture of mobil and disel in 10 ml volume was poured gently on the top surface near the center of the container. An iodine dye was used to color the oil drop to help its identification in photographs. The container containing water and oil was placed on a fairly horizontal platform to limit any chance of movement of water due to slope. It was also ensured that the water surface was properly illuminated to facilitate capturing of photographs. Attention was paid at the time of the experiment so that no wind blows around the water surface which can lead to current or turbulence to the water surface. At the time of deciding the interval it was decided that shorter intervals to be used when there was rapid changes on water surface due to migration of water. The photographs captured were then classified based on image processing techniques. Oil pixels were extracted from classified image. The area covered by individual pixel was determined and was used to calculate the area covered by oil in each image. This was then utilized to analyze the relative rate of dispersion of oil. In order to support the trend in oil dispersion, concentrations of migrating oil were also tried to be observed by taking samples of oil floating at different zones at different intervals. Different zones were spatially differentiated by making nearly square grid with fine threads dividing the top of the container.

3. RESULTS

Photographs were taken at 0 min, 13 min, 19min ,25 min, 40 min etc. At the time of taking photographs visible significant changes in oil occupied pixels were noted. More photographs were taken when significant changes were observed. Widely used ISODATA classification scheme of unsupervised technique was used to classify different images (Fig. 1,2,3, and 4) taken at different time intervals after the beginning of dispersion. Careful observation indicated that at 0 min the oil remained bounded in circular pocket (inside the yellow colored ring in Fig. 1).

The circular oil drop started to migrate and disperse towards north west direction. The enlarged red oil pocket could be found in Fig. 2 at 13th min. The floating oil layer enlarged further in 19 min (Fig. 3, shown in pink color). Fig. 4 indicated that after 25 min the dispersing oil (red colored) had already reached the boundary of the container. The photographs were also taken beyond 40 min (figures are not included here) where the area occupied by oil pixels increased marginally.

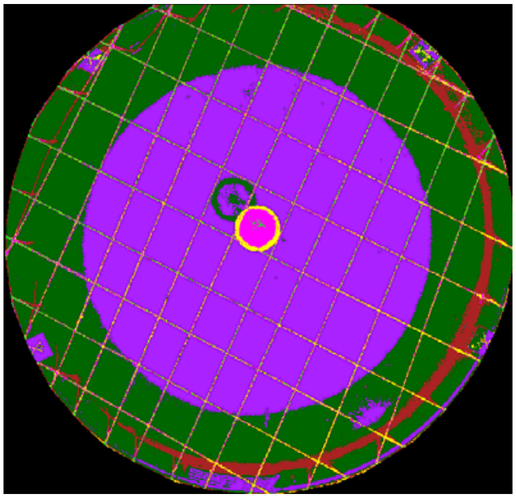

Fig. 1: Unsupervised classified image at 0 min. The classified oil can be located at the center, bounded by yellow colored ring.

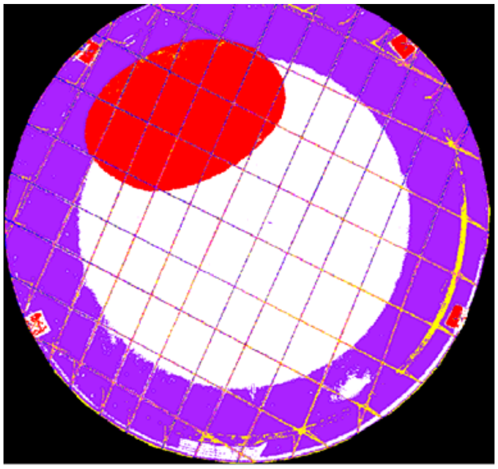

Fig. 2: Unsupervised classified image after 13 min, showing red colored oiled class enlarged in size

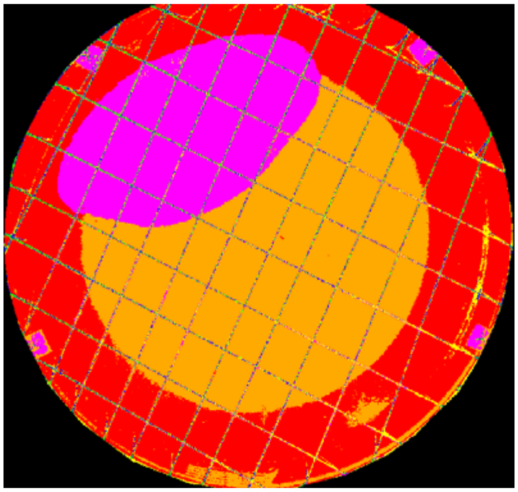

Fig. 3: Unsupervised classified image showing oil class in pink color. The area covered by oil class enlarged further compared to 13th min.

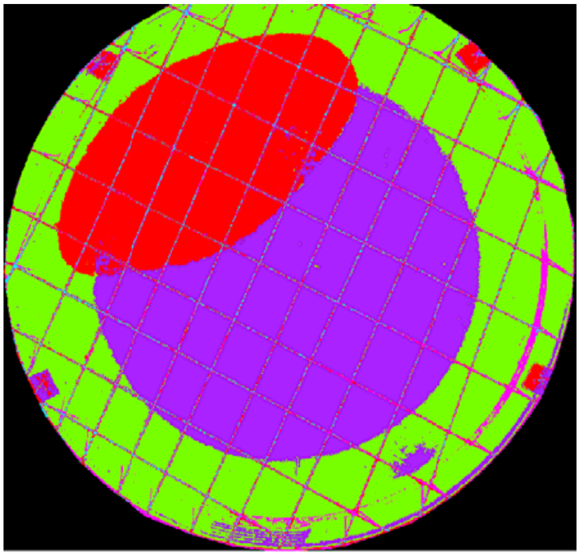

Fig. 4: Unsupervised classified image after 25 min. The enlarged oil class in red color become further larger and reached the boundary of the container.

The classification of oil pixels were also cross checked with visually observed ground truth for oil. The accuracy assessment gave the overall accuracy between 70-75% at different time intervals. The calculation of the area occupied by oil pixels were done to observe the spread of oil with time. At 0 min oil occupied 12.15 sq.cm. It increased to 254.91 sq.cm. after 25 min. The increase in oil occupied pixels with time is shown in Fig. 5. The densities of oil tested at different time intervals indicated a reduction in densities/presence on localized surface of water with time.

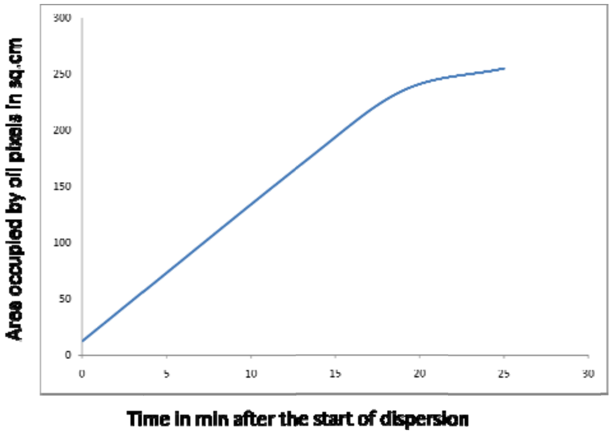

Fig. 5: Nature of dispersion of oil with time

4. DISCUSSIONS

The study indicated that the nature of spatial dispersion of oil with time can be observed through images taken at different time intervals following onset of oil spill. Classification technique can extract oil with reasonable accuracy (70-75%). The migration or nature of dispersion can be noted by visual observation of dynamics and the area coverage with oil. The area coverage indicated that over 200 % area got covered in 25 min. The rate of dispersion was rapid initially about 130% in first 13 min then slowed down. It was reaching saturation after 25 min. The high initial rate of dispersion can be attributed to the higher oil concentration at the beginning. Density of oil also kept on reducing from the beginning as the alternative testes suggested. The technique developed was used to showcase the utility of close range imaging in identifying oil on water and its dispersion with time. The technique can be extended for different types of oil-water interfaces. Further the efficacy of sorbent materials can also be tested using similar experimental and image processing analytical setups.

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