

# Impact of the Tropical Cyclonic Storm ‘Hudhud’ on Northeast Coastal Waters of Visakhapatnam

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**Abstract** Large-scale tropical cyclones, such as tropical storms and hurricanes, can generate both short and long-term disturbances in estuarine systems. The main objective of the present study was to explore and elevate the impact of Hudhud cyclone at three stations of coastal waters along the coast of Visakhapatnam. The physicochemical characteristics of the coastal water vary with pre and post Hudhud cyclone phase. Significant fluctuations were noticed among the hydrographical parameters like salinity, dissolved oxygen, chemical oxygen demand and along with that inorganic nutrients were also enriched during post cyclone event. Collectively, these results demonstrate that storm water runoff from the domestic and sewage drains negatively impacts coastal water quality, both in the surf zone and offshore. However, the extent of this impact and its human health significance is influenced by numerous factors, including prevailing ocean currents, within-plume processing of particles and pathogens and the timing, magnitude and nature of runoff discharged from river outlets over the course of a storm.

**Keywords:** *chemical oxygen demand, dissolved oxygen, Hudhud, salinity, tropical cyclone*

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## 1. Introduction

The Indian subcontinent faced several tropical cyclones through ages [1]. Totally 128 tropical cyclones struck East coast of India during 1804 to 1999. The Bay of Bengal region is among the most impacted regions on the globe, from a socio-economic point of view by tropical cyclones. In India, the state of Andhra Pradesh (AP) is the second most impacted state, just after Orissa, which is also a coastal state lying immediately North of AP [2]. Visakhapatnam coast is considered as one of the productive zones along the Bay of Bengal. The coast line is known for its rich marine life especially intertidal biota [3,4]. Visakhapatnam is highly industrialized shore where human interference to the coastline was high throughout the year. For the first time in Indian Meteorological Department (IMD) recorded history, Cyclone Hudhud ran over a green city like Visakhapatnam, not only damaged the landscape of the port city, but also made it the first city in the country to be directly hit by a cyclone since 1891 as per the records of the IMD. Very severe cyclonic storm Hudhud was the strongest tropical cyclone of 2014 within the North Indian Ocean originated from a low pressure system that formed under the influence of an upper-air cyclonic circulation in the Andaman sea on 6<sup>th</sup> October, 2014 and intensified into a cyclonic storm on October 8<sup>th</sup> and then as a severe cyclonic storm on October 9<sup>th</sup>. This undergone rapid deepening in the

subsequent days and was classified as a very severe cyclonic storm by the IMD. Shortly before landfall near Visakhapatnam, Andhra Pradesh, on October 12<sup>th</sup>, Hudhud reached its peak strength with three minute wind speeds of 175 km/h (109 mph) and a minimum central pressure of 960 mbar (28.35 in Hg) [5]. Recent investigations on numerical simulation of the Bay of Bengal circulation from Ocean General Circulation Model revealed that trapping of Kelvin waves in the central Bay of Bengal boosted humid of the Central Indian Ocean basin and acts as a prospective breeding ground for cyclones. Cyclone affects the components of water cycle such as evaporation, precipitation and evapotranspiration and thus results in large-scale alteration in water present in glaciers, rivers, lakes, oceans *etc.*, [6]. In this case the best suited example is ‘Tiffany’, a tropical cyclone, established impulsive changes in the shelf and slope waters of the southern northwest shelf, Australia [7]. The coasts of Bay of Bengal and Bangladesh were predominantly affected by some precedent cyclones like ‘Sidr’ (hit Bangladesh and Tamil Nadu coast on 14<sup>th</sup> November, 2007), ‘Bijli’ (hit Bangladesh coast on 18<sup>th</sup> April, 2009), ‘Aila’ (hit West Bengal coast and Bangladesh on 25<sup>th</sup> May, 2009) and ‘Phailin’ (hit Gopalpur coast, Odisha on 12<sup>th</sup> October, 2013).

Captivating with the similar previous works [8,9,10], an attempt was made to examine the providence of coastal waters of the Visakhapatnam before and after ‘Hudhud’ occurrence to classify the unevenness of the changed hydrological parameters.

## 2. Materials and Methods

### 2.1. Study Area and Water Sample Collection

Sea water samples were collected in two phases *i.e.*, firstly on 10<sup>th</sup> October and second collection the very next day of cyclone on 13<sup>th</sup> October, 2014. The samples were brought to the laboratory and the parameters namely salinity, dissolved oxygen (DO), chemical oxygen demand (COD), nitrates, phosphates and silicates were analyzed by following the standard methods of APHA, 1995 [11]. Temperature and pH were measured immediately after collection of water sample with the help of the electronic thermometer and portable digital pH meter respectively. Salinity is formally define as the total amount of the dissolved inorganic solids in seawater, expressed as parts per thousand (ppt, ‰) by weight. Salinity in seawater was determined by titration of sample with silver nitrate solution. Dissolved Oxygen (DO) content of the water samples were analyzed by Winkler's method. Chemical Oxygen Demand (COD) was estimated by the open reflux method. Nitrates, phosphates and silicates were measured spectrophotometrically.

## 3. Results and Discussion

The current swot up was to explore and elevate the impact of Hudhud cyclone at three stations of coastal waters along the coast of Visakhapatnam. Locations of three sampling stations that is station I fishing harbour positioned at 17°41'47.63" N 83° 18'12.00" E, station II Ramakrishna beach situated at 17°42'35.87"N 83°19'3.84"E and Jodugullapalem as Station III sited at 17°44'1.09"N 83°20'39.08"E in Visakhapatnam which were located in Northeast Coast of Andhra Pradesh. The main reasons for the selection of these three spots were proximity to open coast and the level of sewage out lets. Map showing the impact of Hudhud Cyclone and GIS sampling stations was put on view in Figure 1 and Figure 2.

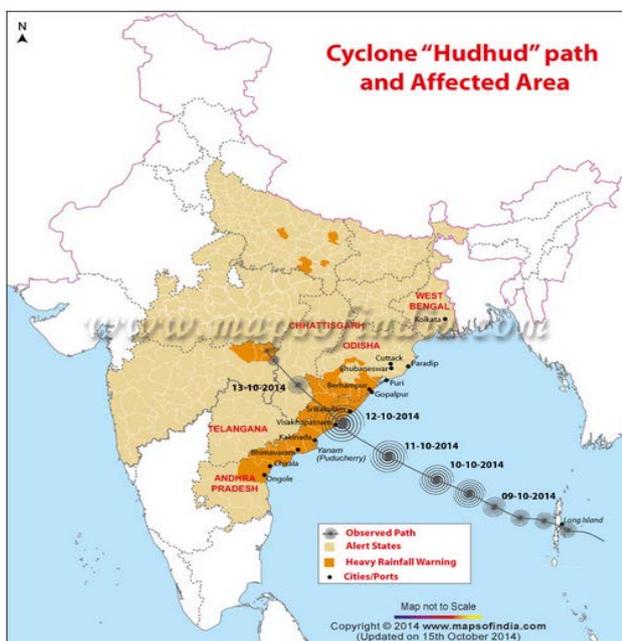


Figure 1. Impact of Hudhud map (Courtesy-www.mapsofindia.com)

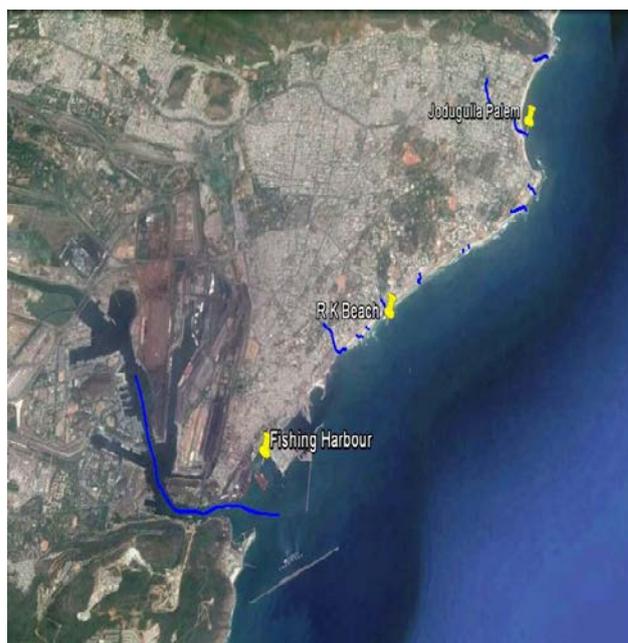


Figure 2. Satellite map - GIS sampling stations

The present study reveals that the hydrographical parameters and nutrients were increased after the Hudhud cyclone. Temperature is one of the most important factors in the coastal ecosystems, which influences the physico-chemical characters of coastal water [12]. Temperature in station II and III illustrate an increasing trend, principally due to sampling time, which were collected in the morning hours at 8.00 AM. The temperature was ranged from 25.7°C to 26.1°C during pre cyclone, whereas 26.5°C to 27.8°C during the post cyclone period. Usually, surface water temperature is influenced by the intensity of solar radiation, evaporation, freshwater influx and cooling. In the present study, summer peaks and monsoonal troughs in air and water temperature has been found to be similar to that reported for west coast of India [13]. Salinity is another important factor which influences the distribution of organisms. The salinity at any point will be dependent on the rainfall and extent of freshwater inflow [14]. In the current evaluation, the post-Hudhud observations have indicated significant decline of salinity in all the three stations. Among three locations, the salinity varied from 25.9±0.33 ppt to 26±0.23 ppt and 18.6±0.48 to 21.4±0.23 ppt. Low salinity, specifically 18.6±0.48 ppt was recorded after Hudhud at Ramakrishna beach area, probably due to the dilution of fresh water ground from the cyclone rainfall into the major outlets of the city. A typical pattern of salinity was observed in the coastal waters of Visakhapatnam with high values of salinity in summer and low values during December. These low values could be attributed to strong southerly surface current that is known to bring large quantities of freshwater during south-west [15].

Alongside with the above, hydrogen ion concentration (pH) gets changed with time due to changes in temperature, salinity and biological activity. The pH of water was important since many biological activities can occur only within narrow [16]. Like temperature the pH values also did not show much spatial variations. The mean values of pH were initially recorded as 7.8 and after cyclone it was 8.3. The rise in pH was probably due to the influence of freshwater influx, dilution of saline water,

reduction of salinity and temperature and decomposition of organic matter [17]. Furthermore, Dissolved oxygen (DO) varied from  $4.4\pm 0.12$  mg/l to  $5.71\pm 0.11$  mg/l and  $3.16\pm 0.14$  mg/l to  $3.6\pm 0.86$  mg/l. The maximum value  $5.71\pm 0.11$  mg/l recorded at station III prior to the cyclone and minimum value  $3.16\pm 0.14$  mg/l was traced at Station II subsequent to the cyclone affect. The two main sources of dissolved oxygen in seawater are diffusion of oxygen from atmosphere and photosynthetic activity of aquatic flora. Levels of DO must be high enough to support the health and well-being of aquatic ecosystems but the effluent discharging directly into coastal waters will decline DO concentration [18].

Low levels of Chemical oxygen demand (COD) were recorded initially before Hudhud event. However, significant rise in COD was observed after Hudhud. The highest COD value was recorded after the cyclone at station I with  $42.7\pm 1.38$  mg/l followed by station II ( $12.06\pm 0.78$  mg/l) and station III ( $5.14\pm 0.92$ ). The increased COD values do not reflect a serious pollution problem but the cyclone rainfall runoffs greatly contribute to the organic matter content. Similar enriched COD values were found during post cyclone impact studies [10]. Positively, spatial and temporal variations in COD concentration were affected by many other factors in addition to the mixing process of fresh water with seawater, and phytoplanktonic photosynthesis [19].

The mean concentration of nitrate was  $12.6\pm 0.69$   $\mu$ g/l and  $49\pm 1.12$   $\mu$ g/l during pre and post Hudhud period correspondingly and the improvement could be related to the local runoff from the adjacent land drains. The nutrients supply will be elevated during high precipitation

and inundation of the coastal regions due to profound rainfall during cyclones. Comparable sort of information's accounted by Reddy *et al* [20] and Satpathy *et al* [21]. In addition, the phosphate concentration was estimated. The mean concentration of phosphate was  $0.23\pm 0.01$   $\mu$ g/l and  $0.71\pm 0.03$   $\mu$ g/l during pre and post Hudhud period in that order. The elevated concentration of phosphate might be derived from domestic sewage containing detergents [22] as well as due to resuspension of the coastal sediments that release phosphate to the water column [23]. Reddy *et al* [20] and Satpathy *et al* [21] accounted similar type of information.

The augment in silicate concentration was also noticed during post-Hudhud period. Mean concentration of pre and post Hudhud period were  $49.74\pm 1.11$   $\mu$ g/l and  $85.87\pm 2.66$   $\mu$ g/l respectively. Similar observations were also made by Satpathy *et al* [21] in Kalpakkam coastal waters for the duration of tsunami. On the other hand, Reddy *et al* [20] not observed any enhancement of silicates in the western coast during the post-tsunami period, in spite of the fact that levels of nitrate and phosphate were high during post-tsunami period. All the above results were displayed in Table 1. Climate change is one of the greatest threats to human lives and livelihoods in coastal regions all over the world. It will significantly aggravate existing hazards such as flooding from cyclones and storm surges. Other climate-induced risks, including sea level rise, salinity intrusion, drought, and temperature and rainfall variations, are becoming serious threats to food, water, energy, and health security for humankind. These changes in the physical and chemical environment will have massive impacts on aquatic ecosystems [24].

**Table 1. Results showing hydrographical parameters and nutrients of water in 3 sampling stations**

Sl. No.	Parameter	Fishing harbour		R K Beach		Jodugullapalem	
		Before	After	Before	After	Before	After
1	Temperature( $^{\circ}$ C)	25.7	26.5	25.9	27.4	26.1	27.8
2	Salinity(ppt)	$25.9\pm 0.33$	$21.4\pm 0.23$	$26\pm 0.18$	$18.6\pm 0.48$	$26\pm 0.23$	$20.1\pm 0.03$
3	pH	7.8	8.3	7.9	8.4	7.9	8.3
4	Dissolved oxygen (mg/l)	$4.4\pm 0.12$	$3.26\pm 0.06$	$5.4\pm 0.63$	$3.16\pm 0.14$	$5.71\pm 0.11$	$3.6\pm 0.86$
5	Chemical Oxygen Demand (mg/l)	$10.5\pm 1.89$	$42.7\pm 1.38$	$2.56\pm 0.36$	$12.06\pm 0.78$	$1.58\pm 0.23$	$5.14\pm 0.92$
6	Nitrates( $\mu$ g/l)	$10.7\pm 0.26$	$38.4\pm 1.36$	$11.6\pm 0.46$	$45.1\pm 1.03$	$15.7\pm 1.36$	$63.5\pm 0.97$
7	Phosphates( $\mu$ g/l)	$0.28\pm 0.01$	$0.54\pm 0.06$	$0.36\pm 0.01$	$0.61\pm 0.011$	$0.32\pm 0.01$	$0.98\pm 0.04$
8	Silicates( $\mu$ g/l)	$54\pm 1.6$	$96.13\pm 2.9$	$49\pm 0.23$	$72\pm 3.16$	$46.23\pm 1.5$	$89.5\pm 1.92$

## 4. Conclusion

The study illustrates the impact of Hudhud cyclone at three specific stations, which exhibit decline in salinity, low down DO and towering COD and inorganic nutrients. The values of these parameters were found beyond the permissible limits. Higher pH values indicate slightly alkaline nature of the water. These findings clearly indicate that selected stations are polluted and eutrophic in nature because of discharge of sewage and other anthropogenic activity beside with cyclone consequence. All above impacts have resulted in the deterioration of water quality. It gives the clue to develop appropriate management strategies by concern authorities.

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## References

- [1] Chittibabu, P., Dube, S.K., MacNabb, J.B., Murty, T.S., Rao, A.D., Sinha, P.C., "Mitigation of flooding and cyclone hazard in Orissa, India". *Natural Hazards* 31: 455-485. 2004.
- [2] Rao, D., Chittibabu, P., Murty, T. S., Dube, S. K., Mohanty, U. C., "Vulnerability from storm surges and cyclone wind fields on the coast of Andhra Pradesh, India". *Natural Hazards* 41: 515-529. 2007.
- [3] Umamaheshwar Rao, M., and Sreeramulu, T., "An ecological study of some intertidal algae of the Visakhapatnam coast". *Journal of Ecology*, 52: 595-616. 1964.
- [4] Prasanna Lakshmi and Narsimha Rao, G.M., "Some numerical studies on marine algae of Visakhapatnam coast". *Journal of Algal Biomass Utiln.*, 1 (1): 60-85. 2009.
- [5] [http://en.wikipedia.org/wiki/Cyclone\\_Hudhud](http://en.wikipedia.org/wiki/Cyclone_Hudhud);  
[http://www.apsdps.ap.gov.in/HUDHUD/Hudhud\\_Report.pdf](http://www.apsdps.ap.gov.in/HUDHUD/Hudhud_Report.pdf).
- [6] Paul, S., Chakraborty A., Pandey, P. C., Bose, S., Satsangi, S. K., Ravichandaran, M., "Numerical simulation of Bay of Bengal circulation features from Ocean General Circulation Model (OGCM)", *Marine Geology*, 32, 1-8. 2009.
- [7] McKinnon, A. D., Meekan, M. G., Carleton, J. H., Fumas, M.J., Duggan, S., Skirving, W., "Rapid changes in shelf waters and pelagic communities on the southern Northwest Shelf, Australia,

- following a tropical cyclone”, *Continental shelf Research*, 23, 93-111. 2003.
- [8] Subhashree Sahoo, Baliarsingh, S. K., Aneesh, A. Lotliker, Sahu, K. C., “Imprint of cyclone Phailin on water quality of Chilika lagoon”. *Current Science*, 107, 9-10. 2004.
- [9] Ajay Debnath, “Condition of Agricultural Productivity of Gosaba C.D. Block, South24 Parganas, West Bengal, India after Severe Cyclone Aila”. *International Journal of Scientific and Research Publications*, Volume 3, Issue 7. 2013.
- [10] Bhaskar Deb Bhattacharya, Asokkumar Bhattacharya, Dibyendu Rakshit and Santosh Kumar Sarkar, “Impact of the tropical cyclonic storm ‘Aila’ on the water quality characteristics and mesozooplankton community structure of Sundarban mangrove wetland”. *Indian Journal of Geo-Marine*, 43 (2), 216-223. 2014.
- [11] American Public Health Association (APHA), Standard Methods for the Examinations of Water and Wastewater. 19<sup>th</sup> edition. American Public Health Association, Washington DC, USA. 1995.
- [12] Sundaramanickam, A., Sivakumar, T., Kumaran, R., Ammaiappan, V. and Vellapan, R., “A comparative study of physicochemical investigation along Parangipettai and Cuddalore coast”. *Journal of Env. Sci. and Technol.*, 1 (1): 1-10. 2008.
- [13] Arthur, R., “Coral bleaching and mortality in three Indian reef regions during an El Nino southern oscillation event”. *Current Science*, 79: 12. 2000.
- [14] McLusky, D.S., “Some effects of salinity on the mud-dwelling euryhaline amphipod *Corophium volutator*”, *Vie milieu*, 22: 135-143. 1971.
- [15] Ganapati, P.N. and Murthy, “Salinity and temperature variations of the surface waters of Visakhapatnam coast”. In: *Andhra Univ. Mem. Ocenogr.*, 1: 125-142. 1954.
- [16] Shephered, J. and Bromage, N., “*Intensive Fish Farming*”, Oxford Blackwell Scientific Publications, London. 1992.
- [17] Zingde, M. D. and Desai, B. N., “Pollution status of estuaries in Gujarat-An overview. Contribution in Marine Science-Dr. Qasim S. Z. Fel S. Vol. ed.: Rao, T. S. S., Natarajan, R., Desai, B. N., Narayanswamy, G., Bhat, S. R., *NIO publ.* 245-268. 1987.
- [18] Smith, K. A. and Otway, N. M., “Spatial and temporal patterns of abundance and effects of disturbance on under-boulder chitons”, *Molluscan Research*, 18: 43-57.1997.
- [19] GAO Xuelu, SONG Jinming, LI Ning, LI Xuegang, “Spatial distribution and diurnal variation of chemical oxygen demand at the beginning of the rainy season in the Changjiang (Yangtze) River Estuary”, *Chinese Journal of Oceanology and Limnology*, 25 (3): 254-260. 2007.
- [20] Reddy, H. R. V., Katti, R. J., Raveesha, K.P., Chandrasekhara, V. S. J., Babu, R. S. N., “Coastal water quality of Dakshina Kannada before and after Tsunami”, *Current Science*, 88, 1026-1027. 2005.
- [21] Satpathy, K. K., Mohanty, A. K., Natesan, U., Prasad, M. V. R., Sarkar, S. K., “Seasonal variation in physicochemical properties of coastal waters of Kalpakkam, east coast of India with special emphasis on nutrients”, *Environmental Monitoring and Assessment*.
- [22] Khaiwal, R., Ameena, M., Rani, M., Kaushik, A., “Seasonal variations in physicochemical characteristics of river Yamuna in Haryana and its ecological best-desiganted use”, *Journal of Environmental Monitoring*, 5, 419-426. 2003.
- [23] Chandran, R., Ramamurthy, K., “Hydrobiological studies in the gradient zone of Vellar estuary-I: physico-chemical parameters”, *Mahasagar Bulletin*, 17, 69-77. 1984.
- [24] Harley, C. D. G., Hughes, A. R., Hultgren, K. M., Miner, B. G., Sorte, C. J. B., Thornber, C. S., Rodriguez, L. F., Tomanek, L. and Williams, S. L., “The impacts of climate change in coastal marine systems”, *Ecology Letters* 9 (2): 228-241. 2006.