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The Study of the Vulnerability of the East Coast India

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Abstract : *The paper indicate a prolonged research work conducted by the researcher. The east coast of India is extremely dynamic in nature. In some parts it is propagating and in some parts it is retro getting in nature. Both sub aerial and sub-marine process are prominent over here and these are controlling the geomorphology of the east-coast. Objective : The main objective of the study is(i) the study of the geomorphology of the coast.(ii) the study of the phase wise changing nature of the coast.& (iii) the study of the ocean wave and cyclonic storms in the coastal morphology. Methodology : In the study the researcher has followed three phase Methodology i.e.(i) in the pre-field phase the researcher has collected map of the area and has also collected so many books related to the study.(ii) in the phase of the field the researcher has conducted a survey work in the nine important points in the east coast by Dumpy level at an interval of consecutive five years.(iii) in the third phase depending on the surveyed date researcher has analysed the changeable nature of the coastal morphology by graphical representation of the data as well as made a correlation between changing morphology of the coast and the submarine process.*

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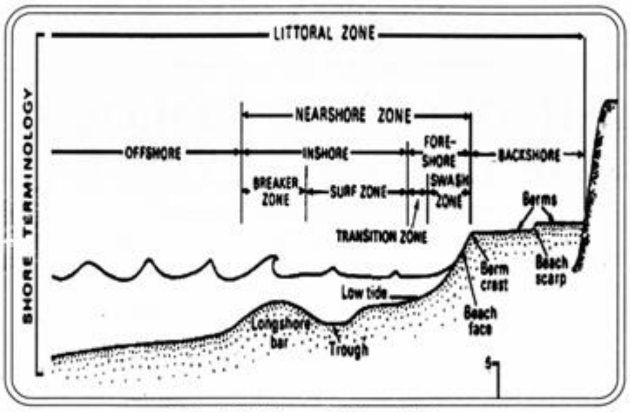
I. Introduction

The geomorphology of the east coast depends mainly on the land forms and various processes acting on it. Both sub-aerial and sub-marine processes act on the littoral zone form prominent cliff features, sand dunes and organic deposits at the land ward side of the sea beach

Offshore area : Over this area shallow water moves slowly and sometimes effects by the sinusoidal wind wave and creates solitary wave towards the shore

Breaker zone : in this zone incoming waves become unstable and break. A series of ridge or ridges aligned parallel to the coast is composed of sand are common in the high water breaker zone and are exposed at the low water tide. In the eastern coast parallel ridges are more stable because of the continuous tectonic processes occur at the eastern coast is caused by the impact of 90^{O}E rise within Indian Ocean.

Surf Zone : This zone experiences turbulent bore like translation waves which may cause the movement of long shore current through the depression which occurs shore ward side of the long shore bar.



Major Divisions of Littoral Zone

Swash Zone : It is the most steeply sloping zone which is effected by swash and backwash, that is the zone lying between the hightidal wave or swash and the lower-limit of the tidal wave i.e. back wash.

Such a difference between the two tide levels is not uniform in each and every part of the eastern coast. But as the whole coast is propagating in nature so it is clear that there should be some uniformity in the behaviourial pattern of the swash and back wash.

Back shore zone : It is the zone known as Berm which normally indicates the zone lies above the normal high-tide level. In the east coast of India berms are composite in nature and in most of the cases berms crest and multiple berms and separated by beach scraps and their average height is normally 1 to 1.5 m high. Gravels, Cobbles and Boulders are found in the backshore zone lifted upward by the excessively high tide level caused by cyclonic storms. These materials normally take part in abrasion and destroy beach scarp in most of the cases under the action of near about 0.5 high waves.

Imman and Nordstorm (1971) have indicated that Indian coast developed on the stable plate zone. But in most of the cases the coastal tracts of Indian indicate variegated land form features and behave like secondary coast (Shepard's 1963) because changeable storm wave environments and swell wave environment in different parts on India.

The study of the coastal tracts on and from Digha, West Bengal to the lake Chilika Orissa indicate storm wave environment and swell wave environment. As a result chaotic water movement normally occurs above the shallow water. The increase in the height of the wave normally decreases the wave length which may cause more wave steepness as the wave move towards the coast.

The typical coastal tract of east coast represents multitude activities performed by the coastal processes. These are -

(i) The shoaling transformation of the wave phase velocity is of great importance to wave behaviour in shallow water. In this process,

i. e. $\mathbf{C = \sqrt{gd}}$ Where g : acceleration due to gravity

d : horizontal distance

the formation of wave crests normally cause variation in coastal geomorphology.

(ii) In shallow coastal tracts of Orissa and West Bengal the wave breaking is prominent. Which may be defined as solitary wave theory under which a continuous process of deposition, which have caused broad flat troughs. The wave forms velocity mainly depends on the depth of the water bodies and also the height of the water.

Crests move quickly or faster i.e.

$\mathbf{C = \sqrt{g(d + H)}}$ Where g = Acceleration due to gravity

d = horizontal distance.

H = height of the wave.

But while it is trough it is slower i.e.

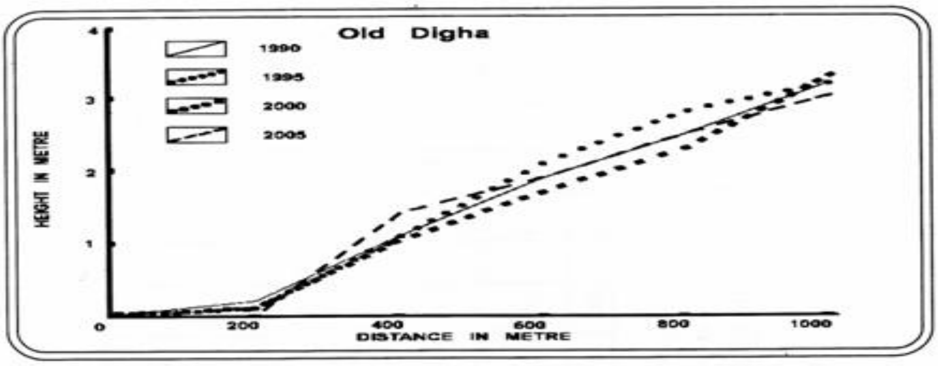
$\mathbf{C = \sqrt{g(d - H)}}$

In some areas of steep slope leading edge of the surface and gentle back have caused asymmetrical waves which may cause instability.

No, wave is sufficient in itself but it may explain the phenomenon of wave breaking. So, to study the wave breaking it is necessary to study the break point and water depth relationship. The study of Shankarpur coast near Digha at West Bengal represents that the low waves run much shallower water than the high waves of water before breaking, it is also observed at the Gopalpur coast and Chilika coast of India. As per Galvin (1972) the ratio between depth and wave height is more or less constant and is termed as gamma (g) ratio. In value varies from 0.6 to 1.2 and the mean is 0.78. The equation is

Average Condition of The Leveling Survey Started From Backwash Point

	All diamention are in Mts.																			
	1990					1995					2000					2005				
	200	400	600	800	1000	200	400	600	800	1000	200	400	600	800	1000	200	400	600	800	1000
Shankarpur	0.2	0.8	1.3	1.9	0.2	0.2	0.7	1.1	1.6	2.3	0.15	0.6	0.9	1.4	2.05	0.1	0.5	0.8	1.3	1.9
Old Digha	0.2	1.94	1.90	2.5	0.1	0.1	1.85	2.1	2.8	3.2	0.1	1.45	1.7	2.3	3.3	0.05	1.4	1.9	2.5	3.35
New Digha	0.1	0.6	0.9	1.2	0.1	0.1	0.65	0.8	1.1	2.0	0.05	0.8	0.9	1.00	1.85	0.05	0.8	0.9	1.20	1.95
Puri	0.4	1.9	2.4	2.7	0.3	0.3	1.9	2.3	2.7	3.6	0.2	2.0	2.4	2.6	3.7	0.2	2.1	2.45	2.6	3.5
Gopalpur	0.2	0.6	1.0	1.2	0.2	0.2	0.7	0.9	1.1	2.2	0.1	0.7	0.8	0.9	1.8	0.1	0.9	1.5	1.6	1.9
Chilika	0.2	0.7	0.9	1.1	0.1	0.1	0.6	0.9	1.2	1.95	0.1	0.5	0.95	1.3	2.0	0.05	0.5	1.0	1.4	2.2
Vizag	0.3	2.0	2.8	3.2	0.2	0.2	1.8	2.2	3.1	3.9	0.1	1.75	1.9	3.0	3.8	0.05	1.4	1.8	2.8	3.75
Chennai	0.4	0.9	1.7	2.2	0.3	0.3	1.4	1.8	2.4	3.1	0.2	1.5	1.9	2.4	3.2	0.15	1.6	1.9	2.5	3.3
Pondicheri	0.35	1.9	2.75	3.2	0.3	0.3	1.8	2.5	3.0	3.8	0.2	1.6	2.0	2.3	3.1	0.1	1.5	1.8	2.5	3.0


Old Digha
1990
1995
2000
2005
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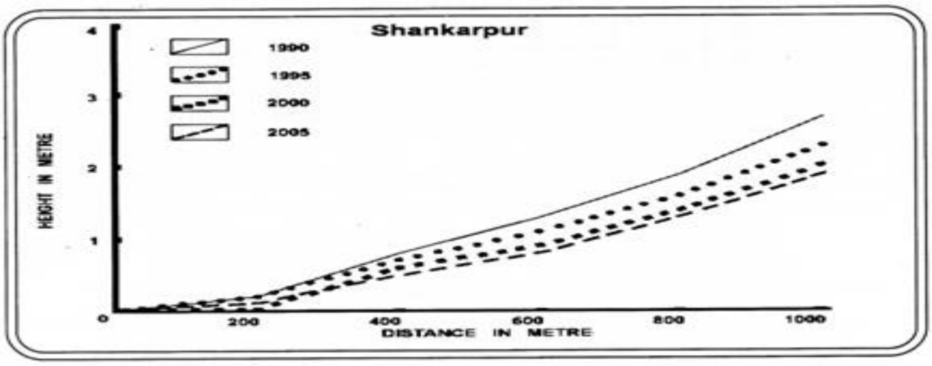
600
800
1000
DISTANCE IN METRE


Shankarpur
1990
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HEIGHT IN METRE
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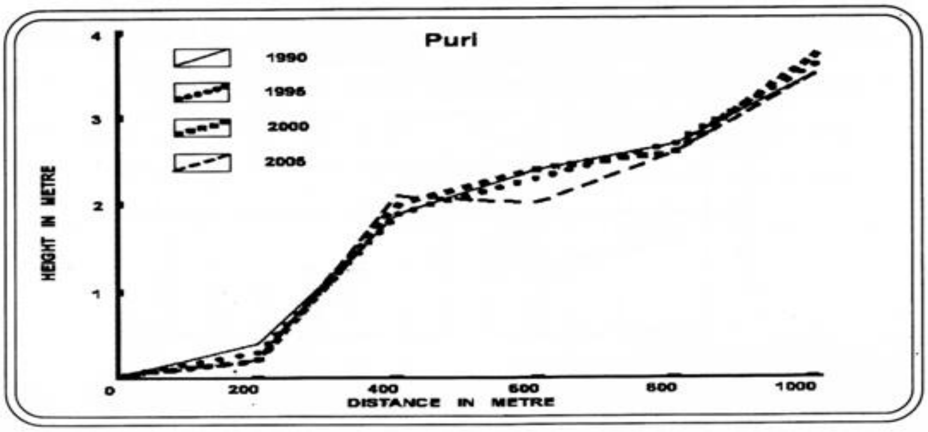
DISTANCE IN METRE


Puri
1990
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HEIGHT IN METRE
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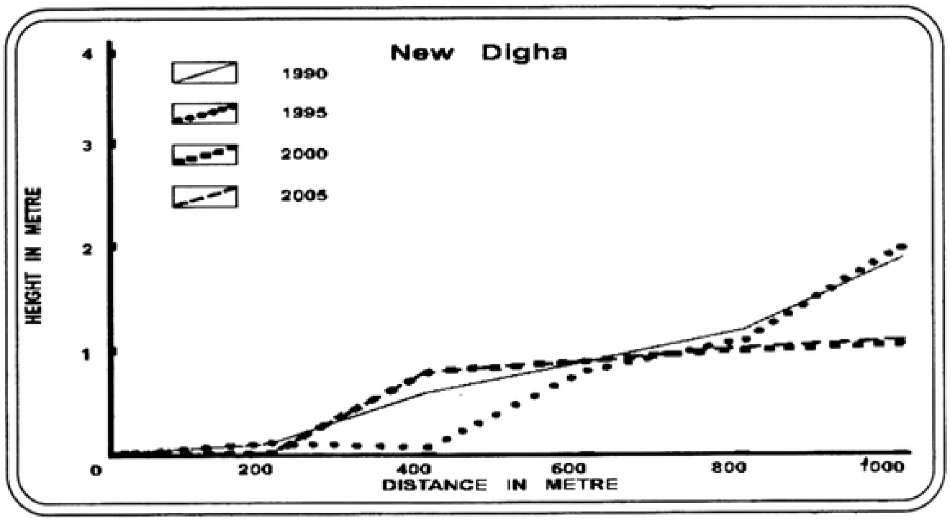
New Digha
1990
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HEIGHT IN METRE
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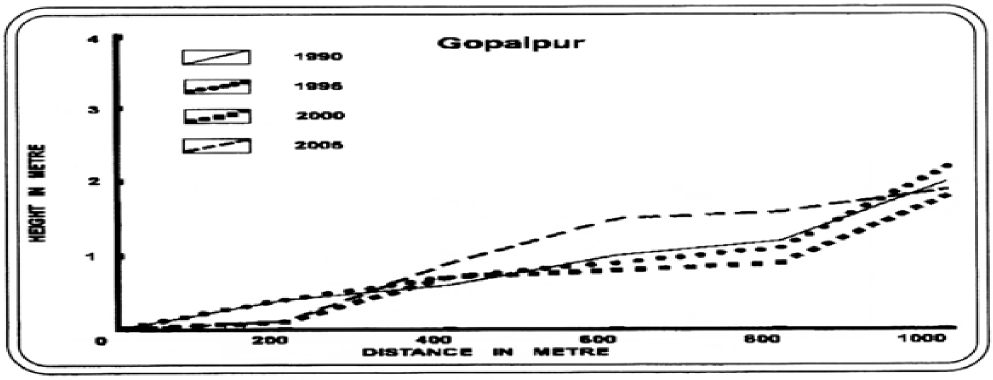
Gopalpur
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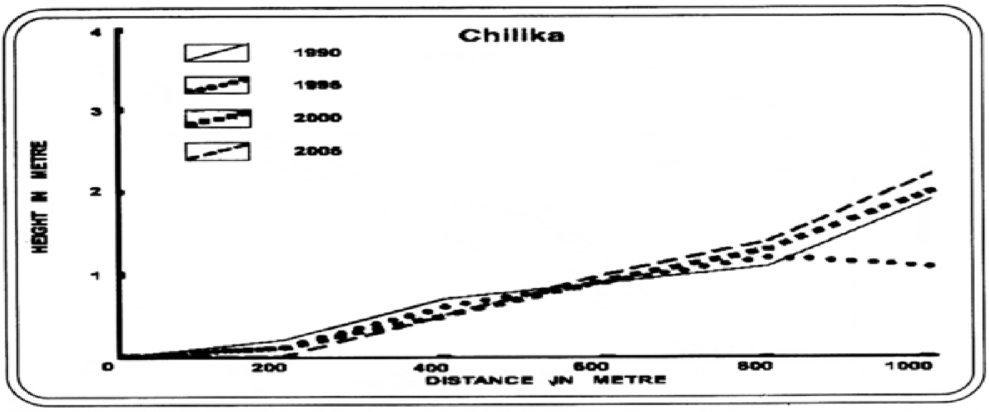
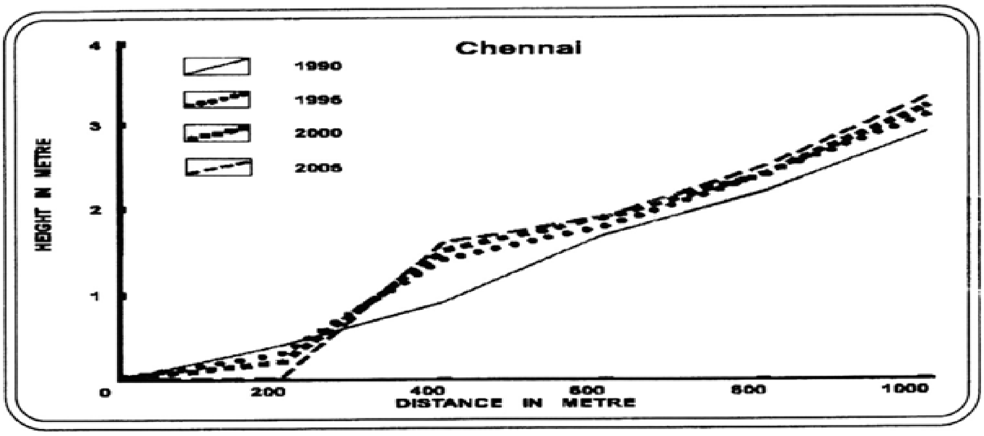
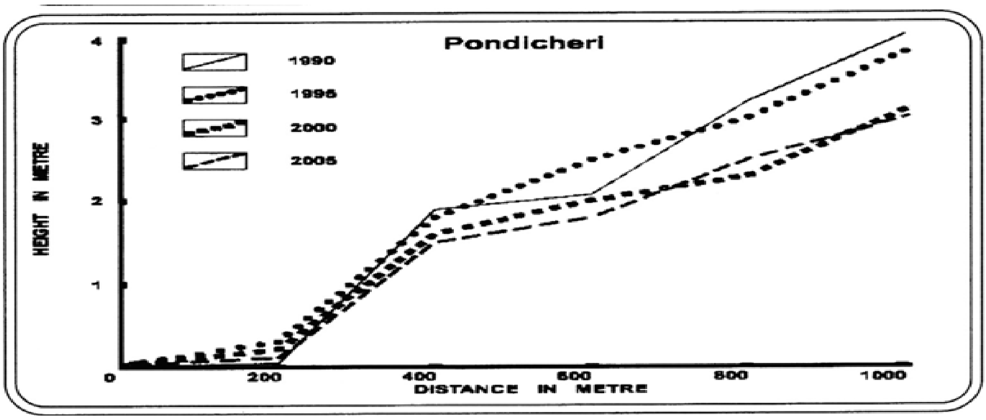
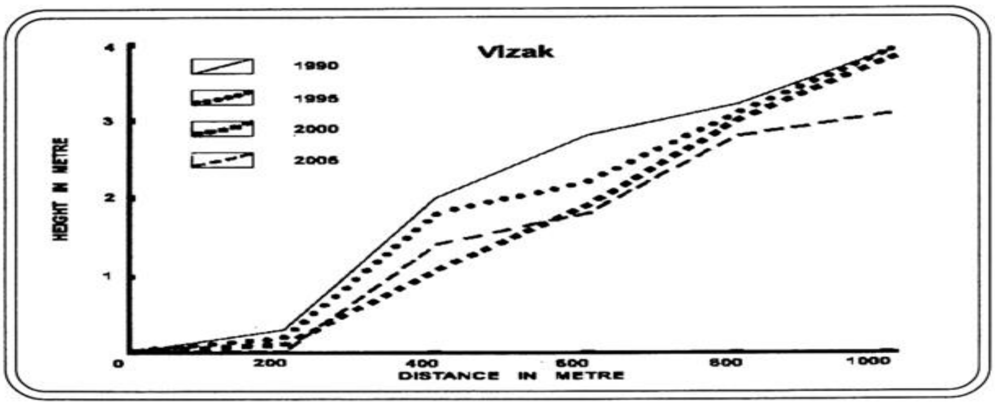
HEIGHT IN METRE
DISTANCE IN METRE


Chilika
1990
1995
2000
2005
HEIGHT IN METRE
DISTANCE JN METRE


Chennai
1990
1995
2000
2005
HEIGHT IN METRE
DISTANCE IN METRE


Pondicheri
1990
1995
2000
2005
HEIGHT IN METRE
DISTANCE IN METRE

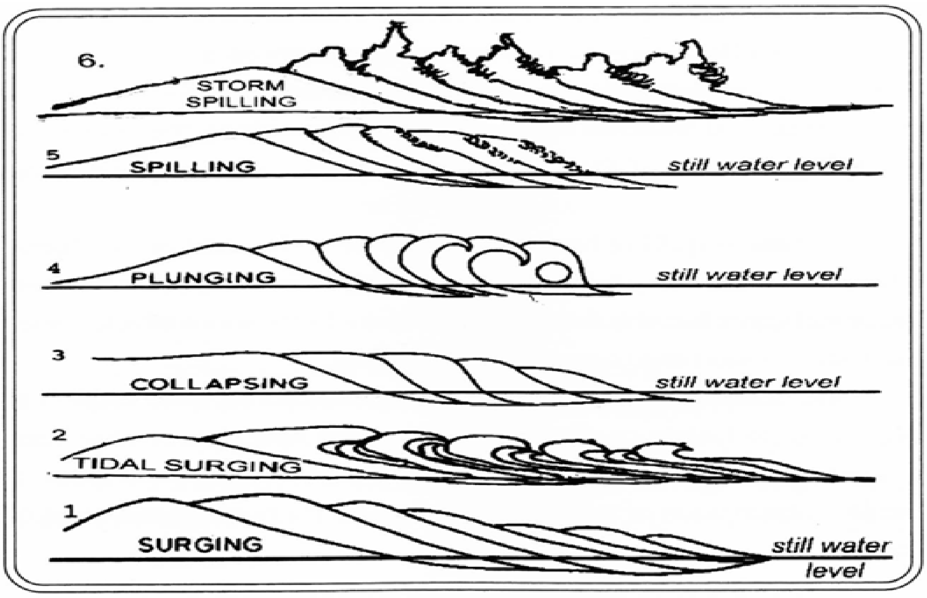


$$g = \frac{H}{d} = 0.78$$

Where H = *Height of the wave*
& d = *depth of the water*

The study of the eastern coast of India indicates that in Puri, Vizag, Chennai, Pondichari, the value of g is nearer to 1.2 due to presence of steep beaches and it is nearer to 0.6 at Shankarpur, New Digha, Gopalpur, Chilika and Dhanuskoti in Rameswaram are due to the presence of flatter beaches.

Previous diagram indicates the various cross section along the coast by Dumpy level survey. Galvin (1972) has suggested four basic types of breakers. But for eastern coast of India I may suggest 6 breakers. These are 1. Surging, 2. Tidal Surging, 3. Collapsing, 4. Plunging, 5. Spilling, 6. Storm Spilling.



Typical Six Breaker Types of East Coast

1. Surging breaker normally it is observed in the coast of Konkan and in some parts of the lower reaches of Uttar Sirkar. Here flat and low waves run along the steep beaches.

2. Tidal Surging breaker is a typical surging breakers observed mainly at the coast of vizag. Here undulating low waves run along rugged beach, cause maximum erosion and then slide smoothly from up to down beach.

3 & 4. Collapsing breakers and plunging normally is observed at the coast of Puri, Gopalpur, Paradwip and Chilika. In these coasts waves break by curling there crests over the gentle rolling slope and in these coasts plunging occur by anticurling towards the dip of the beach.

5. Spilling breaker, it is normally observed at the coast of Shankarpur, Digha & Balasore. Here comparatively short and high waves run over the flat beaches and break before reaching the shore and move as the thin line of foam and form the typical nature of propagating coast.
6. Storm spilling breaker it is observed at the coast of old Digha, where thin line of foam formed by the spilling breaker on the wave crest becomes bigger form by the surges and strike to the shore which cause excessive erosion and form retrogetting coast.

Guza and Imman (1975) has formulated surf scalling factor (e) depending on Galvin coefficient (1972) and in later phases it has been utilised by Wright et al (1979) for field investigation as applied by me in the field observation of the geomorphologic study of the east coast of India.
Depending on the surf scaling factors.

$$\varepsilon = \frac{a.2\Pi}{g \tan^2\beta}$$

Where a.2P = *Wave height and volume*
g = *Gravitational acceleration*
T = *Wave time*
b = *Inclination of one Bach*

We may explain that from Digha to Chilika in most of the cases the value of 'e' ranges between 13 to 27 indicates plunging to spilling types of breakers, whereas from Chilika to Kanyakumari the value of e is less than between 2.5 indicating surging to plunging breakers.

Kemp (1975) has indicated run-up i.e. the movement of water towards the up-beach is the interaction between shore wards flow of water and breakers. It has been observed that after the breaking of waves the rotational movement of water decreases. But as storm surges the rotational movement of water get maximum horizontal component and thus increase orbital velocity

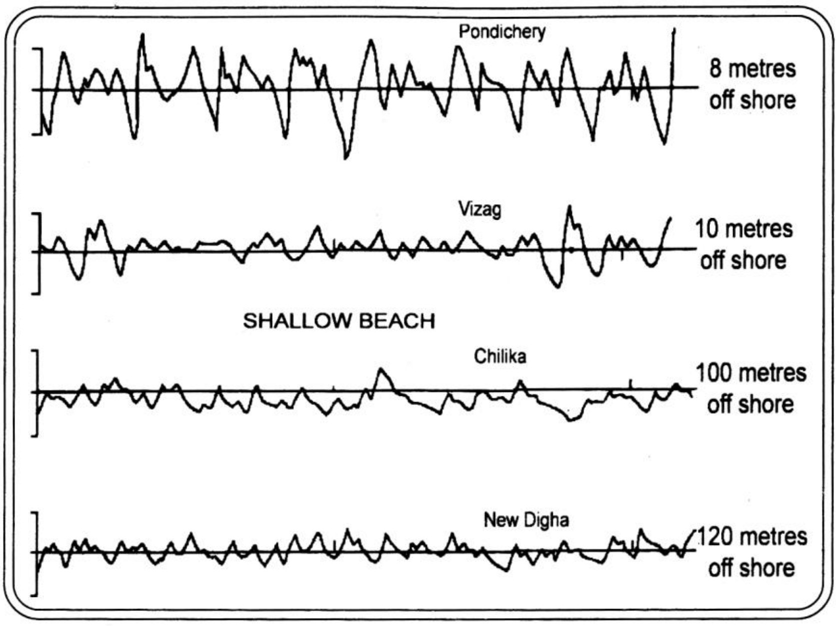
$(U_o = \frac{g}{2}\sqrt{gd}$, (Huntlay and Bowen, 1975)

Where g = **height and depth ratio**
g = **Gravitational acceleration**

which causes maximum erosion on the beach

In these profile of shore currents, asymmetry of waves shown by field measurement. It is also prominently observed in these Diagrams that there is a marked difference between peaked crests and flattened trough of the waves. The asymmetry has caused due to the configuration of the coast and as well as structural control over the beach.

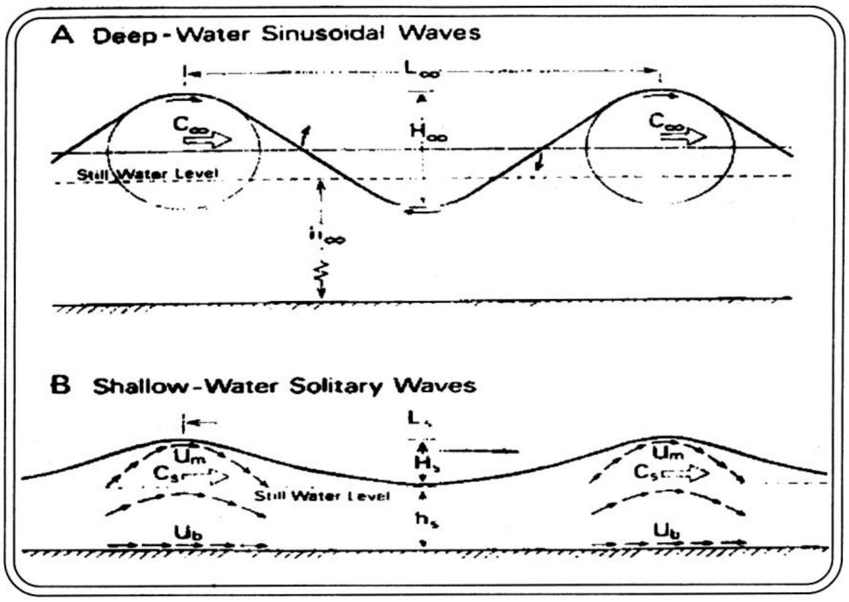
Almost all coastal part of eastern India experience fluctuation in sea level of 25-35 cm.



On shore current Asymmetry Beneath Waves Shown By Field Measurement of more due to the interaction of (i) **density and the temperature of sea water,** (ii) **Atmospheric pressure changes and the changing sea level,** (iii) **Changes in the speed of ocean currents,** (iv) **Water locked up in winter in the North and South polar region and** (v) **Seasonal pilling of water at the wind ward side.**

Wave Character

Winds normally generate waves. Deep water wind generated waves involves sinusoidal motion where the water moving into the shallow sea waves begin to decrease velocity and wave length. As a result they cause solitary waves over the beach surface.



Water Particle Movement A. Deep Water Sinusoidal Wave
& B. Shallow Water Solitary Wave

$C\mu = \sqrt{[gL\mu / 2P]}$ Where g = *gradient*
L = *wave length*
and 2P = *Diameter regulated periphery of circular orbits.*

Sinusoidal waves are normally found in old Digha coast, Vizag, Chennai coast. Here the relation with phase velocities may be expressed and as the steep surface slope cause sinusoidal motion we may express orbital velocity be means of

$Um = (PH\mu / T\mu)$

Where H = *height of water increase directly with the wind speed and gradient*
T = **Wave period**

Thus orbital velocity measures the ratio between height of wave and the wave period which directly or indirectly indicate orbital velocity.

In the case of solitary waves as found in the coastal tracts may be explained by the equation –

$C_s = \{g (h_s + H_s)\}$ Where g = *gravitational acceleration*
h = *depth of the water body*
H = *height of waves*

The orbital velocity gains maximum speed at the crest of the waves. When the height and depth ratio exceeds 0.8m it form the unstable coast and break the steep continental mass to form retro getting coast as observed in the Digha Coast.

Vulnerability of the Coast

The Indian coast is extremely vulnerable in nature in the context of -

(i) The coastal geology and their evolutionary process.

(ii) The impact of tides, waves, storm surges and tectonic activities in the delta development process.

(iii) The activities performed by the various geomorphic processes.

(iv) The various stages of the evolution of delta.

(v) Continuous destruction activities performed by the coastal dwellers mainly in the areas of Mangroves, swamps and on tidal inlets and on lagoons.

(vi) It is an area of typical denudation chronology mainly depends on the positive and negative movement of base level.

(vii) Such a typical polycyclic landform indicates the complex morphogenetic behaviour of the physiographic and morphology relationship.

(viii) In the last 130 years the continuous occurrence of Depression. Strom and severe storm crossing the coast line have caused the coast most vulnerable.

(ix) Due to global warming sea level is rising day by day which may cause coastal inundation in some parts of the Coastal expansion.

(x) Presently the El-nino impact and ENSO Phenomena over the Bay of Bengal have caused the east coast to be more complex and vulnerable.

Management of the Coast

To protect this vulnerable coast we may adopt some management techniques. These are as follows :

(i) More research is necessary to create a proper data base regarding the impact of various processes acting over the coast.

(ii) The mangrove swamps should be well managed because it may control the storm surges, manage the berm extension and as well as may protect the area from severe cyclonic hazard.

(iii) The Management of mangrove swamps is also necessary to maintain the bio-diversity of the coastal ecosystem.

(iv) The agriculturists should be properly trained so that they can adopt the coastal management technique and follow the way of social forestry.

(v) A-forestation techniques should be properly managed and for this purposes trees and plants suitable for this area should be taken into consideration. It not only protects the coast from soil erosion but also protects the coast from severe storm and storm surges.

At last we must say that the positive impact of human being will protect the coast from its vulnerability.

Acknowledgement

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