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Breaker wind waves energy at Iraqi coastline

A.B. Mahmood, A.A. Al-Mahdi and S.S. Abdullah
Marine Physics Department, Marine Science Center, Basrah University, Iraq

Abstract Hydrographical survey were carried out for four cruises during the period 22 March to 9 May, 2007 by Marine Science Center team in the Iraqi marine water. By using the prediction method of Karsten , the breaker wave height root mean square H_{rms} was computed as a function of water depth and the breaker wave energy was computed as a function of H_{rms} in Mean Higher High Water (MHHW) for 45 points at the Iraqi coastline in the north of the Arabian Gulf. The results showed that the gradient of Iraqi coast at the study area was flat and the predominant type of breaker waves was spilling.The highest value of the energy of these waves was 1214,258992 J/m^2 at point no. 45. The highest breaker wave height root mean square H_{rms} was 0.981 m at the same point.

Introduction

The Iraqi coast region is located in the extreme south of Iraq. Tigris, Euphrates and Karun rivers have one of the most prominent influences on the coast surface and its topography which led to the coast slope formation from the north and north-west towards the south and south-west along the coast (Al-Musawi, 1993). The gradient of the coast is towards the Arabian Gulf and this region is almost devoid of terrain symptoms. Al-Hashemi (1986) recorded that the gradient of tidal zones is 15 cm/km and the gradient gradually moves from the subtidal zone towards the sea water submerged up to 35 cm/km. The erosion and sedimentation at the Iraqi coastal region depends on the physical processes such as duplication tides, river runoff and waves heights (Kassler, 1973).

The aim of this research was to compute the breaker wave height root mean square as a function of water depth at breaking in mean higher high water (MHHW) by using the model of Karsten (2004), then computing the breaker wind wave energy as a function of this height at the Iraqi coastline for 45 points. The water depth at Iraqi coastline was measured by Marine Science Center team in the period 22/3/2007 to 9/5/2007. The coast gradient was computed in this research to determine the breaker wave type at the above mentioned points of the Iraqi coastline.

Intertidal Flats:

The region which includes most parts of the Iraqi coast is called Marakkat Abdullah, which defines the features and extends over the range between the high tide level and low tide level. At high tide this region represent the turbidities water zone, which consist of soft sediments cause the formation of the banks to the coast during low tide, where most of its parts are exposed or covered with a shallow layer of water (Al-Husseini, 1988). Although, it is difficult to determine the rate of expansion towards the Gulf because of the range of variation provides by the tide. But the expansion is estimated around 15000 meters near Ras Al-Beshah with light gradient towards the Arabian Gulf, and about 100 meters near the entrance of Khor Al-Zubair. However, most of the deposition is silt with less clay towards the shore, while sand is almost non-existent (Al-Mahmood, 2006).

Breaker wind waves:

This is the surface undulations or rising up in water surface by the wind blowing over the sea and occurs at sediments barriers which formed the Iraqi coast, where waves cause the formation of topographic feature of the coast. It is possible to reflect the characteristics of the validity of coast construction and coastal traffic.

The influence of wind will be more on the open coasts (Selim, 1986). The north-western and south-eastern wind affect the water surface causing wave heights, and because of the straitening of the Arabian Gulf and its shallow depths have prevailed favorable conditions to break the waves near the coast (Abboud, 1996).

Waves breaking:

As swells approach the shallow water they will feel the bottom and their speed will slow down. The wave will become overtaken by waves following behind and when it gets into a depth its height called critical height, the frictional resistance caused by the bottom makes the crest topple over; however, the breaking waves will occur when orbital velocities, increasing towards the coast exceed the wave phase speed which decreases in the landward direction. The breaker wave height root mean square H_{rms} is related to the water depth at breaking, h_b through the relation below (Karsten, 2004):

$$H_{rms} = \langle \gamma_{rms} \rangle h_b \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where γ is the breaker index. In nature waves are irregular and random and using H_{rms} as a measure of wave height, the maximum time-averaged value of the breaker index ($\langle \gamma_{rms} \rangle$) is in the order of 0.35-0.5. The fact that wave heights within the surf zone are depth-limited means that wave heights approach a linear function of water depth.

Breaker waves energy:

The energy possessed by a wave is in two forms:-

1- Kinetic energy, which is the energy inherent in the orbital motion of the water particles,
2- Potential energy possessed by the particles when they are displaced from their mean position.

The total energy (E) per unit area of a wave is given by Brow *et al.* (1989):

$$E = (1/8)\rho g \, H_{rms}{}^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where ρ is the density of water which is 1.03 x 10^3 $k.gm^{-3}$; g is the acceleration due to gravity which is 9.8 $m.s^{-2}$, H_{rms} in m. The energy (E) is expressed in Joules per square meter ($J.m^{-2}$).

Beach Gradients:

Beach gradients or underwater slope is usually expressed as a ratio of depth to horizontal distance. Beach gradients are usually described as-

- Steep (more than 1:15).
- Moderate (1:15 to 1:30).
- Gentle (1:30 to 1:60).
- Mild (1:60 to 1:120).
- Flat (less than 1:120).

All these figures are in feet units. Steep beaches have gradients of more than 1:15. These beaches normally have plunging breakers, but if the gradient is very steep, breakers of an unusual type may exist. Beaches with slopes of 1:15 to 1:30 are with moderate gradients. Plunging breakers are less common on these beaches. Spilling breakers occur most frequently. The probability of each type of breaker depends on the topography of the beach and the type of waves that exist. Beaches with slopes of 1:30 to 1:300 have gentle, mild, or flat gradients. Plunging breakers are less common on these beaches; spilling breakers are the rule. Plunging breakers are usually the result of a temporarily steep section of the profile.

Study area:

The Iraqi marine waters are natural prolongation of the north-western end of the Arabian Gulf, which differs significantly from the rest of the Arabian Gulf as far as the physical oceanography and the Hydrology are concerned. Iraqi marine waters can be divided into three major areas (Figure 1), namely:

Shatt Al-Arab Estuary:

This region is shared between inland brackish water and marine water and extended from the head of the estuary at Al-Fao until the mouth in the supreme approaches of the outer bar. The Deep Khors Region is Khor Al- Amaya and Khor Al-Kafka. These Khors are narrow valleys and sharp with a depth of about 30 meters.

Khor Abdullah Region:

Khor Abdullah is a body of water of funnel form separates the Iraqi lands and the Bubiyan island, which is recognized by its relatively shallow depth. The navigation channel is close to the Bubiyan Island than to the Iraqi coasts. Khor Al-Zubair lies in the north-west of Khor Abdullah.

Materials and Methods

On the nineteenth of February 2007, the level (Bench Mark) was moved from Al Fao entrance district B.M1 which was (3.169 m) E 48^{o} 26 '56.164 "& N 29^{o} 59' 12.434" and attributed to the sea level using the device DGPS Tremible R7 Model 5700. The UTM coordinates (Universal Transverse Mercator) that was adopted at the World Stereogram WGS 84 (World Geodetic System 84) was used in the process of transferring the Bench Mark. The station's main base was installed on Al Fao entrance and used the rover movement of a 3 km distance where a strong signal was obtained from the main station. The point was measured and called Measured Point.

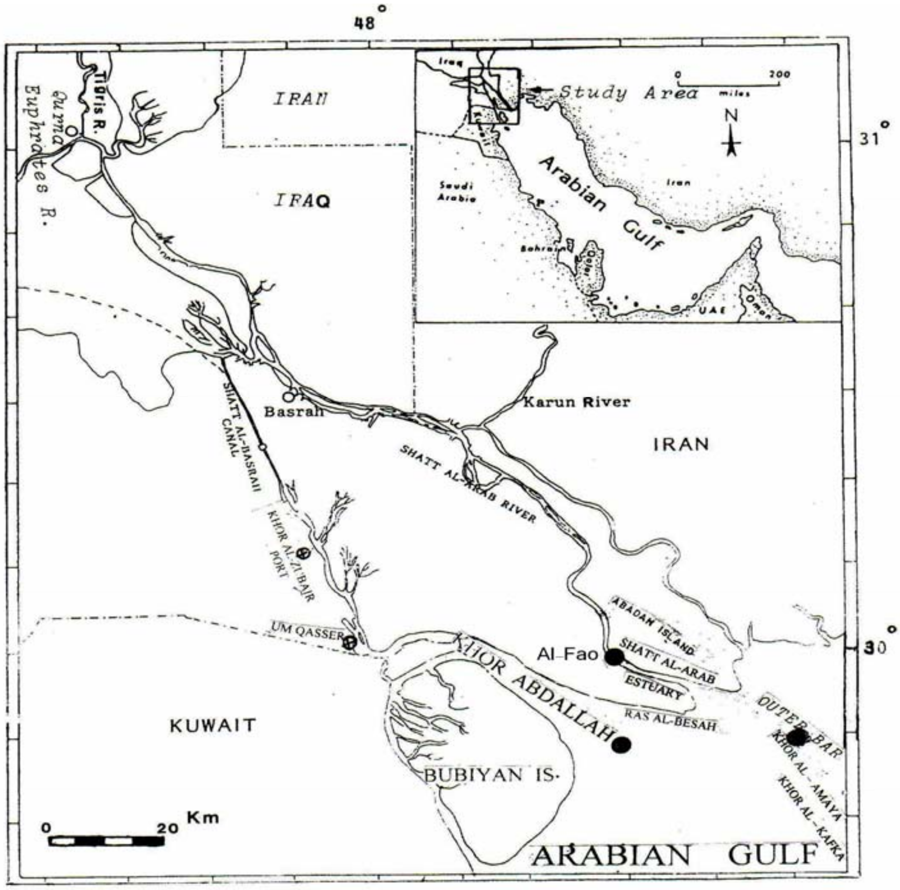

Figure 1. Iraqi marine water at the north part of the Arabian Gulf.

A main station erected again at the point measured and considered the basis for the transfer of B.M2 which was (1.923 m) and have the coordinates of E 48° 26 '19.39 "& N 29° 58' 14.46". The point was transferred to the intermediate points such as B.M3 which is (1.656 m) E 48° 26 '50.99 "& N 29° 55' 35.83" and the point B.M4 which was (2.285 m) E 48° 26 '26.64 "& N 29° 54' 48.95" then transferred to Lesan Al-Medina Al-Monawera at Khor Abdullah coast configured B.M5 which was (1.926 m) E 48° 26 '25.1 "N & 29° 54' 34.4" (Figure 2). These have been installed as reference points of the study area for the measurement of sea level (Vertical Datum) in relation to the Local Vertical Datum in the region. Before initiating the process of hydrographic survey, several poles were placed and distributed over the survey region which have been marked by the low tide index levels in the region (each region has accounts of their own based on the region hydrology). Their reading was recorded by the observer to the level of fluctuation of the surface water every ten minutes during the hours of high tide of the day, and coinciding with the hydrographic survey. Hydrographic survey was carried out during four cruises from 22 March to 9 May, 2007.

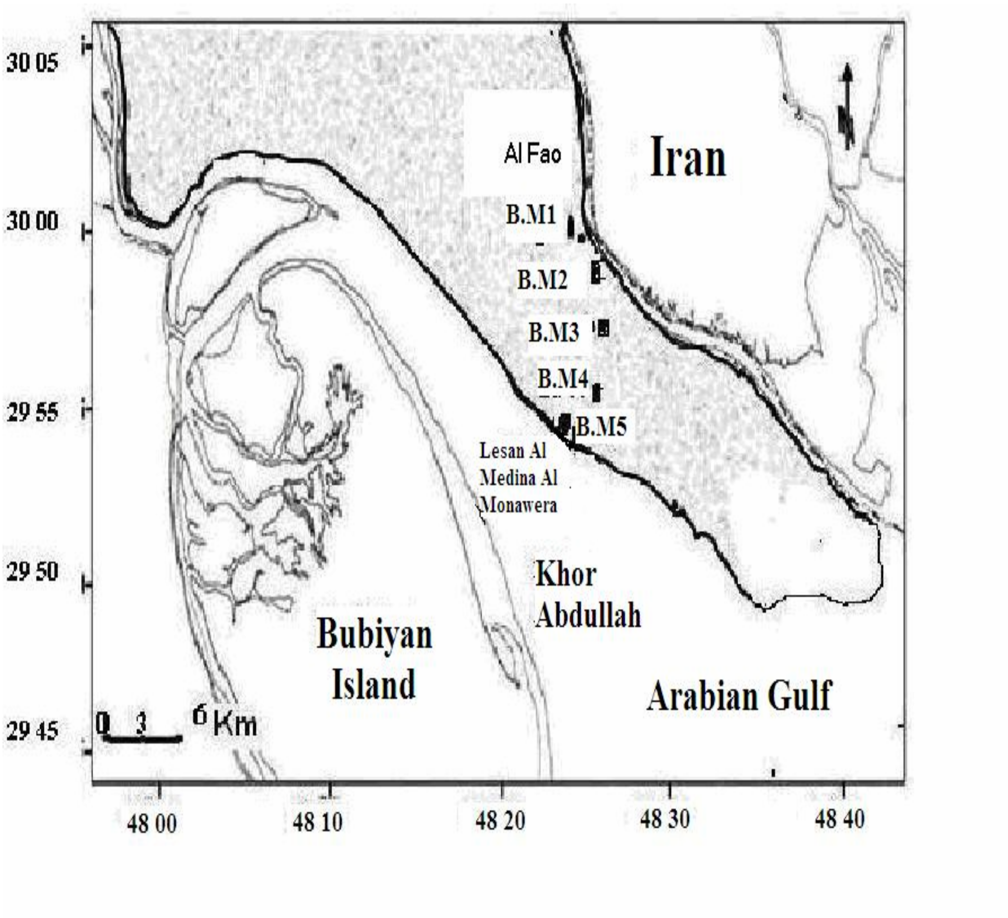

Figure 2. Bench Mark Locations

All hydrographic surveys were conducted within the periods before, during and after the high tide hours using the Odom Hydrotrac Precision Survey Echo Sounder model HT97001 which was installed on the survey boat. The survey area was divided into 45 cross sections. The distance between each two stations was 500 m. The starting and end points must be determined for each cross section using GPS Model 128 type Garmin.

A survey device sensor was fixed on the body of the boat and at a depth of 50 cm beneath water surface. The hydrographic survey process begins at each cross section in conjunction with the movement of the boat at constant speed and in the desired direction. It was defined by using the GPS system and the use of UTM coordinates, adopted by the World Stereogram WGS 84 (World Geodetic System 84) in the process of hydrographic surveys.

Results

The breaker wave height root mean square H_{rms} was computed by using eq. (1) as a function of water depths in mean higher high water (MHHW) at the 45 points of Iraqi coastline which were measured by the hydrographic survey. The breaker wave energy as a function of H_{rms} was computed from eq. (2). Gradients of the Iraqi coast were computed by dividing water depth at breaking (which is equal to the difference between the mean higher high water point to the mean lower low water point) by the horizontal distance of the tidal zone at each of the 45 points of the Iraqi coastline. The results showed that the gradient of the Iraqi coast at the study area was flat and the breaker wave type at these coastline points was spilling.

These results agreed with the measurements of Selim (1986). The breaker wave height root mean square (Table 1) was less than one meter and this was in accordance with the field measurements of the Iraqi Ports Company which refered to the low and moderate waves in the head of Arabian Gulf, quiet and less than one meter in height in more than 75 % of the time in the Arabian Gulf (Aboud, 1996). The highest breaker wave height root mean square H_{rms} was 0.981 m at point no. 45 due to the highest tidal range at this point. The highest value of breaker wave energy was 1214, 258992 J/m^2 at point no. 45 where the highest wave possessed high energy as a kinetic and potential energy and release this energy when break at the breaker point of the coastline. Tables 1 and 2 illustrated these results. Fig. 3 illustrated that the wave heights approaches a linear function of water depth, so it is possible to use Karsten (2004) method at study area. The results as follows:-

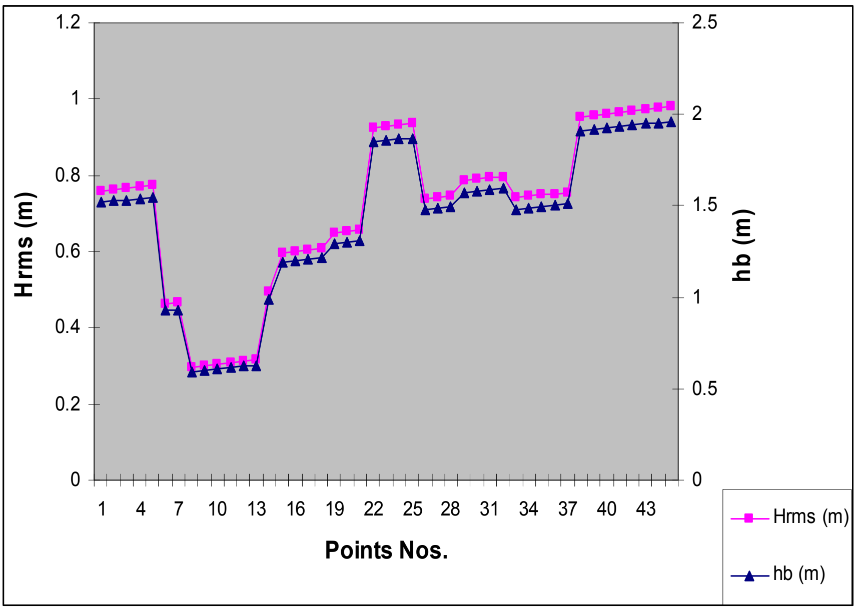

Figure 3. Relation between H_{rms} & h_b at every point of the Iraqi coastline.

Table 1. Breaker wave height root mean square H_{rms} and the breaker wave energy E as a function of H_{rms}.

Points Nos.	h (m)	h_b (m)	H_{rms} (m)	E (J/m²)
1	3.78	1.5176	0.7588	726.4871849
2	3.78	1.5252	0.7626	733.7817654
3	3.78	1.5328	0.7664	741.1127853
4	3.78	1.5404	0.7702	748.4802445
5	3.78	1.548	0.774	755.884143
6	3.15	0.9256	0.4628	270.2464601
7	3.15	0.9332	0.4666	274.7026078
8	2.8	0.5908	0.2954	110.1017686
9	2.8	0.5984	0.2992	112.9526675
10	2.8	0.606	0.303	115.8400058
11	2.8	0.6136	0.3068	118.7637833
12	2.8	0.6212	0.3106	121.7240002
13	2.8	0.6288	0.3144	124.7206565
14	3.15	0.9864	0.4932	306.9159433
15	3.35	1.194	0.597	449.6990558
16	3.35	1.2016	0.6008	455.4420875
17	3.35	1.2092	0.6046	461.2215586
18	3.35	1.2168	0.6084	467.0374691
19	3.42	1.2944	0.6472	528.5064971
20	3.42	1.302	0.651	534.7309118
21	3.42	1.3096	0.6548	540.9917657
22	3.95	1.8472	0.9236	1076.319384
23	3.95	1.8548	0.9274	1085.194281
24	3.95	1.8624	0.9312	1094.105618
25	3.95	1.87	0.935	1103.053394
26	3.55	1.4776	0.7388	688.6952489
27	3.55	1.4852	0.7426	695.7980434
28	3.55	1.4928	0.7464	702.9372773
29	3.62	1.5704	0.7852	777.9181337
30	3.62	1.578	0.789	785.4658718
31	3.62	1.5856	0.7928	793.0500491
32	3.62	1.5932	0.7966	800.6706658
33	3.5	1.4808	0.7404	691.6814579
34	3.5	1.4884	0.7442	698.7995953
35	3.5	1.496	0.748	705.954172
36	3.5	1.5036	0.7518	713.1451881
37	3.5	1.5112	0.7556	720.3726435
38	3.89	1.9088	0.9544	1149.302032
39	3.89	1.9164	0.9582	1158.47228
40	3.89	1.924	0.962	1167.678967
41	3.89	1.9316	0.9658	1176.922093
42	3.89	1.9392	0.9696	1186.201659
43	3.89	1.9468	0.9734	1195.517664
44	3.89	1.9544	0.9772	1204.870108
45	3.89	1.962	0.981	1214.258992

Table 2. Breaker types and coast gradients.

Points Nos.	Long. E	Lat. N	Horizon. Dist. (m)	h_b (m)	Breaker Type
1	32 ′ 30.0 ″°48	52 ′ 08.5″°29	14001.093	1.5176	Spilling
2	32 ′ 46.0 ″°48	51 ′ 04.1 ″°29	13500	1.5252	Spilling
3	33 ′ 03.0 ″°48	52 ′ 02.2 ″°29	13000	1.5328	Spilling
4	33 ’ 21.0 "°48	52 ′ 03.0 "°29	13300	1.5404	Spilling
5	33 ’ 42.0 "°48	51 ’ 59.6 "°29	12800	1.548	Spilling
6	34 ’ 00.0 "°48	51 ’ 59.6 "°29	13600	0.9256	Spilling
7	34 ’ 21.9 "°48	51 ’ 43.0 "°29	14200	0.9332	Spilling
8	34 ’ 42.0 "°48	51 ’ 53.1 "°29	16600	0.5908	Spilling
9	35 ’ 00.0 "°48	51 ’ 18.7 "°29	18000	0.5984	Spilling
10	35 ’ 21.6 "°48	51 ’ 31.7 "°29	18500	0.606	Spilling
11	35 ’ 38.7 "°48	51 ’ 20.1 "°29	18700	0.6136	Spilling
12	35 ’ 56.1 "°48	51 ’ 45.6 "°29	22000	0.6212	Spilling
13	36 ’ 17.4 "°48	51 ’ 13.4 "°29	20300	0.6288	Spilling
14	36 ’ 36.9 "°48	51 ’ 13.4 "°29	12800	0.9864	Spilling
15	36 ’ 52.0 "°48	51 ’ 13.4 "°29	9500	1.194	Spilling
16	37 ’ 13.7 "°48	51 ’ 38.5 "°29	10000	1.2016	Spilling
17	37 ’ 34.0 "°48	51 ’ 38.5 "°29	8700	1.2092	Spilling
18	37 ’ 52.5 "°48	51 ’ 36.0 "°29	9000	1.2168	Spilling
19	38 ’ 12.0 "°48	51 ’ 37.7 "°29	9300	1.2944	Spilling
20	38 ’ 31.7 "°48	54 ’ 27.3 "°29	8000	1.302	Spilling
21	38 ’ 50.5 "°48	54 ’ 29.7 "°29	9300	1.3096	Spilling
22	39 ’ 11.5 "°48	54 ’ 05.0 "°29	9500	1.8472	Spilling
23	39 ’ 28.0 "°48	54 ’ 05.0 "°29	9600	1.8548	Spilling
24	39 ’ 47.0 "°48	53 ’ 34.0 "°29	8500	1.8624	Spilling
25	40 ’ 06.0 "°48	53 ’ 34.0 "°29	9600	1.87	Spilling
26	40 ’ 25.5 "°48	53 ’ 27.3 "°29	13500	1.4776	Spilling
27	40 ’ 42.5 "°48	53 ’ 20.3 "°29	14000	1.4852	Spilling
28	41 ’ 04.4 "°48	53 ’ 20.1 "°29	14100	1.4928	Spilling
29	41 ’ 22.5 "°48	53 ’ 20.2 "°29	13000	1.5704	Spilling
30	41 ’ 42.0 "°48	53 ’ 27.3 "°29	13300	1.578	Spilling
31	42 ’ 01.5 "°48	52 ’ 39.1 "°29	14000	1.5856	Spilling
32	42 ’ 20.7 "°48	52 ’ 35.0 "°29	14700	1.5932	Spilling
33	42 ’ 39.0 "°48	52 ’ 39.1 "°29	15100	1.4808	Spilling
34	42 ’ 57.5 "°48	52 ’ 12.8 "°29	15200	1.4884	Spilling
35	43 ’ 16.7 "°48	52 ’ 15.5 "°29	16700	1.496	Spilling
36	43 ’ 36.5 "°48	52 ’ 15.5 "°29	16300	1.5036	Spilling
37	43 ’ 55.8 "°48	52 ’ 15.5 "°29	16600	1.5112	Spilling
38	44 ’ 15.0 "°48	52 ’ 15.5 "°29	15600	1.9088	Spilling
39	44 ’ 34.5 "°48	51 ’ 27.3 "°29	15500	1.9164	Spilling
40	44 ’ 52.6 "°48	51 ’ 27.3 "°29	17000	1.924	Spilling
41	45 ’ 12.0 "°48	50 ’ 22.7 "°29	16500	1.9316	Spilling
42	45 ’ 31.7 "°48	50 ’ 22.7 "°29	17600	1.9392	Spilling
43	45 ’ 51.0 "°48	50 ’ 07.5 "°29	18500	1.9468	Spilling
44	46 ’ 09.3 "°48	50 ’ 07.5 "°29	18700	1.9544	Spilling
45	46 ’ 28.5 "°48	50 ’ 07.5 "°29	19500	1.962	Spilling

Conclusions

1- The highest value of breaker wave energy was 1214, 258992 J/m^2 at point 45.
2- The highest value of breaker wave height root mean square was 0.981 m at point 45.
3- The breaker wave height root mean square was less than one meter at the study area.
4- The breaker wave height root mean square approached a linear function of breaker water depth at study area.
5- The type of the coast gradients at the study area was flat.
6- The prevailing wave breaker type at the Iraqi coastline was spilling breaker.
7- The prediction method of Karsten (2004) was used in this study and gave reliable results.

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طاقة أمواج الرياح المنكسرة عند الشريط الساحلي العراقي

علي باسل محمود، أياد عبد الجليل المهدي و صادق سالم عبد الله
قسم الفيزياء البحرية، مركز علوم البحار، جامعة البصرة، العراق

المستخلص أجريت عمليات المسح الهيدروغرافي في المياه البحرية العراقية من قبل فريق مركز علوم البحار التي امتدت للفترة من 22 مارس إلى 9 مايس 2007. استخدم النموذج المقدم من قبل Karsten لحساب الجذر التربيعي لمعدل ارتفاع الأمواج المنكسرة H_{rms} كدالة لأعماق هذه الأمواج ونتيجة لذلك حسبت الطاقة المتولدة من انكسار الأمواج كدالة لـ H_{rms} في معدل أعلى مد ولخمس وأربعين موقعا منتشرا على الشريط الساحلي العراقي في شمال الخليج العربي. وقد أظهرت النتائج إن نوع انحدار الساحل في منطقة الدراسة كان مسطح وان نوع الأمواج المنكسرة على الساحل كان من النوع المتدفقة (المنسكبة) على طول الشريط الساحلي في منطقة الدراسة. وان أعلى قيمة لطاقة هذه الأمواج كانت (J/m^2) 1214,258992 في النقطة 45، وأعلى قيمة للجذر التربيعي لمعدل ارتفاع الأمواج المنكسرة H_{rms} كانت 0.981 m في النقطة 45.