

**Report of the Sub-Committee constituted by the Ministry of Environment and Forests (MOEF) in pursuance to the Direction of Hon'ble High Court of Judicature of Andhra Pradesh at Hyderabad (Special Original Jurisdiction) dated 29<sup>th</sup> June, 2009 in respect of Writ Petition No. 13341/08 filed by Krishna Godavari Deltala Parirakshana Samithi, Bhimavaram, West Godavari District in Andhra Pradesh & Others Vs Union of India & Others.**

As per the directive of the Hon'ble High Court of Andhra Pradesh in Writ Petition No. 13341/08 filed by Krishna Godavari Deltala Parirakshana Samithi, Bhimavaram, West Godavari of Andhra Pradesh, the Ministry of Environment and Forests constituted a Committee (Annexure-1) with the following Terms of Reference (TORs):

- (i) Examine and scrutinize the applications, pre-feasibility and EIA reports received by the Ministry for exploration and development drilling activities for oil and gas in the KG basin in Andhra Pradesh and study the aspects of land subsidence.
- (ii) The Committee shall visit selected sites in oil and gas exploration blocks in the KG basin;
- (iii) The Committee shall also consider the contents of the Writ Petition and representation received by the 1<sup>st</sup> respondent from the petitioner within 15 days of the Hon'ble High Court order dated 29<sup>th</sup> June, 2009.
- (iv) The Committee may co-opt additional members, if required.
- (v) The Committee may convene its meeting(s) anywhere in the country.
- (vi) The Committee shall submit the report to the Ministry for assessment by the Expert Appraisal Committee (Industry)-2. The Expert Appraisal Committee-2 shall send its recommendations to the Ministry within two months well in

advance of the next hearing before the Hon'ble High Court of Andhra Pradesh in the first week of November, 2009.

2.0 The Committee had its first meeting on 17<sup>th</sup> September, 2009 in MOEF, New Delhi and had presentations from M/s Oil & Natural Gas Corporation Limited (ONGC) as well as Directorate General of Hydrocarbon (DGH) and chalked out the programme for the site visit, discussion with the Petitioners as well as with the other Operators in the KG Basin.

3.0 Since, Prof. G S Roonwal could not attend this meeting and expressed his inability to come for the site visit because of his earlier commitments, the Committee co-opted Dr. R Ramesh, from Institute of Ocean Management (IOM), Anna University, Chennai, a member of the Expert Appraisal Committee (Infrastructure), MOEF, as an Expert in Geology.

The Committee visited the exploration cum production site both Onshore and Offshore during 9<sup>th</sup> -10<sup>th</sup> October, 2009. The Committee had also discussions with petitioners including Prof. G. Krishna Rao who had sent representation after the High Court Order. The Committee also visited some of the sites in the villages alleged to have been affected due to subsidence close to the Oil & Gas fields. On 8<sup>th</sup> October 2009 at Hyderabad, the Committee had discussions with all the operators in the KG Basin namely M/s Cairn Energy, M/s Gujarat State Petroleum Corporation (GSPC), M/s Oil and Natural Gas Corporation Limited (ONGC) and M/s Reliance Industries Limited (RIL).

## **Background**

4.0 An NGO by name Krishna Deltala Parirakshana Samithi, Bhimavaram, and two others filed a Writ Petition in the High Court of Andhra Pradesh on the following issues:

- i. The problem of subsidence and other geo-hazards due to large scale exploitation of Oil & Gas in Krishna - Godavari

- ii. Basin, Andhra Pradesh could have grave consequences, but has not been considered.
- iii. As a result of subsidence the ground water in the area has become saline, and immediate measures need to be taken to tackle the problem. This has happened due to ingress of sea water into the ground water of shallow dug wells of domestic use and also into surface water of canals.
- iv. In support of their apprehension of the subsidence caused in this region they have cited the example of other countries namely, United States of America (USA), Netherlands & Italy, where substantial land subsidence has taken place in some of the areas where Oil and Gas has been exploited.
- v. In the representation sent by Prof. Krishna Rao, and during presentation before the Committee, he made the point that KG delta is a sensitive and fragile area. Although land subsidence study has been carried out in the Cambay Basin, such a study has not been done here. He suggested to carryout the following studies for clinching the issue of land subsidence in the KG Basin:
  - a) to draw topographic contours of the KG Delta using Remote Sensing Techniques in the pre production period (1990) and the present period to identify the areas subjected to subsidence.
  - b) to determine the co-efficient of compressibility and co-efficient of consolidation of the reservoir rocks.
  - c) to carry out modeling studies to predict land subsidence both due to onshore and offshore production and to determine the influence of offshore production on the delta area.
  - d) to evaluate the possibility of slipping of the delta or submarine mass movement.

e) to evaluate the other geo-hazards which could affect the delta region as well as the coastal belt.

## **5. Observations and findings:**

- 5.1. It has been reported that land subsidence can be caused by large scale extraction of underground water, Oil & Gas, and underground mining and in certain parts of the world, subsidence has actually been observed. Of course there can be other causes, natural as well as man-made for land subsidence.
- 5.2. A change in levels of delta has also been reported particularly where-ever major dams have been constructed up-stream of the deltas, due to non availability of sediments, after the construction of the dams.
- 5.3. Although land subsidence has been reported as a result of exploitation of Oil and Gas in certain parts of the World, it is also reported that “notable subsidence above producing Oil & Gas fields is the exception rather than the rule” (Reference J.Geertsma, SPE-AIMA, Koninklijke/shell Exploratie en Produktie Laboratorium, Journal of Petroleum Technology, June, 1973). The incidence of land subsidence and its magnitude depend upon various factors viz:
  - a) the nature of formation
  - b) the depth of reservoir
  - c) the extent of the reservoir
  - d) the reservoir pressure
  - e) the quantity of hydrocarbon extracted
- 5.4. Comparing the KG Basin in India with the fields in other countries where subsidence has been reported, the following differences are observed:
  - The extent of reservoir in KG Basin is much smaller as compared to the other areas in the world where

subsidence has been reported. It is in small stretches.

- The depth of occurrence of the Hydrocarbons (Oil & Gas) varies from 1800 m to 4100 m in KG Basin as compared to about 1000 m in other countries where subsidence has occurred. Further, the thickness of the reservoir is much less (2-10 m) in KG Basin compared to more than 300 m in the other countries.
- The age of the KG basin is older and has been subjected to consolidation and compaction as compared to the other areas which have undergone subsidence, which are younger, loose and unconsolidated.
- The reservoir pressure in case of the KG basin is very small as compared to pressure in other countries where subsidence has been reported.
- The quantity of hydrocarbon extracted from KG basin is much smaller. Even as compared to the Cambay basin, it is only 5% so far.

5.5. Two studies on subsidence in the Cambay Basin in India conducted by Indian institute of Technology (IIT), Mumbai and Central Mining Research Institute, (CMRI) Dhanbad were brought to the notice of the Committee. As per DGH representative, these studies were carried out because of the likely land subsidence there in view of the nature of the geological formation and shallow depth of the reservoir.

The investigation carried out by Central Mining Research Institute (CMRI), Dhanbad during August, 2004 to June, 2005 and again in November, 2006 and November, 2007 for the Bhima Gas Field (Block CB-ONN-2000/2) near Surat,

Gujarat where the gas reservoir is at shallow depth, led to the following conclusion:

- a) “No land subsidence movement has been observed for pressure depletion of 1.6 - 4.7 kg/cm<sup>2</sup>. However, pressure depletion in the range of 7.2 - 12.5 kg /cm<sup>2</sup> showed subsidence of 162 mm, slope of 1.73 mm/meter and compressive and tensile strain of 1.42 and 0.75 mm/meter. On the other hand the subsidence, slope, compressive and tensile strains for the same pressure depletion namely 7.22 - 12.5 kg/cm<sup>2</sup> in deep gas reservoir were 37 mm, 0.78mm and 0.36 mm/m and 0.20 mm/m respectively.
- b) There was no change in the water level except the seasonal variations.
- c) All the villages lying above the gas reservoir are safe as the magnitude of the ground movements is well within the safe limits. It is recommended to monitor ground movements and water level in wells periodically”.

This study has shown that the subsidence is a function of the pressure of the reservoir and its depth.

Another study carried out by IIT, Mumbai between February, 2004 and May, 2006 for measurement of ground levels using GPS led to the following conclusion:

“From GPS derived elevations, it is concluded that deformation stations within the reservoir boundary are showing significant vertical deformations compared to the stations outside the reservoir boundary. Average subsidence over the study area is found to be 49 mm while subsidence within reservoir boundary is found to be 81 mm during two years. Two subsidence bowls were observed, a big subsidence bowl was observed in the area, where more numbers of gas extracting wells are situated.

Correlation coefficient between cumulative gas extraction and cumulative changes in elevations is found to be very high and linear relationship is estimated. Hence, land subsidence found with GPS method might be due to extraction of gas. From the consistent monitoring of deformation stations over nine campaigns, it has been observed that, in general land is showing downward movement before monsoon and upward movement after monsoon. This can be attributed to seasonal change in water level. No permanent depletion in water level has been observed over the study area. So observed subsidence can not be attributed to ground water extraction.

To study and monitor subsidence and to find the rate of subsidence, extensive monitoring for longer duration is required. These are the preliminary results of the studies; hence the rate of subsidence in the area has not been established. In future , rigorous monitoring will be done to find the rate of subsidence and other geodetic techniques like leveling in Synthetic Aperture Radar Interferometry (SAR) techniques will be implemented to validate the Global Positioning System (GPS) derived results. “

5.6 From the data provided by DGH, it is learnt that the total KG Basin delta area is about 28,000 km<sup>2</sup>. Out of this, about 8,300 km<sup>2</sup> has been licensed for petroleum exploration and only 700 km<sup>2</sup> has been converted into mining lease. The quantity of oil production from the basin in the delta region is about 0.28 million tonnes per year and of gas 1566 million SCM per year which is a very small fraction of the county's production and of areas in countries where land subsidence has been reported. The Committee was informed that so far mainly ONGC has been producing hydrocarbon in the on-shore part of the KG basin.

5.7 From the above, it appears that KG Basin is not prone to land subsidence as a result of Oil and Gas extraction. However, it may be advisable to carry out periodical monitoring of the ground levels at selected locations near the fields.

5.8 The Committee was provided data by M/s ONGC office at Rajahmundry in respect of ground level measurements at KG wells which have been in operation. The baseline measurement was carried out during the period 1998 -2000. For the same locations, the measurements have been taken during 13<sup>th</sup> -18<sup>th</sup> September, 2008. However, the data collected earlier was by auto level instrument where as the data in 2008 has been collected by Differential Global Positioning System (DGPS). From the data it appears that the two methods of measurement are giving slightly different values and therefore it is difficult to compare the difference in ground levels, if any, during the period 1997-2000 and Sept, 2008.

For a proper comparison it was considered necessary that the measurement be done using the same instrument/method. Since GPS data for the period 1997-2000 may not be available, ONGC was asked to carry out existing ground level measurement using the earlier instrument i.e. Auto level instrument. As per the suggestions of the Committee, ONGC again carried out ground level measurements in some of the same locations, from October 19<sup>th</sup> to 21<sup>st</sup> , 2009 with Auto Level. Results of these measurements along with the earlier one are given in Annexure-2. There are minor variations in the levels now measured as compared to 1997-2000 ( in fact the levels now measured are higher than the earlier levels), they could be taken as measurement variations. Thus there appears to be no change in levels over the last 9-13 years.

A more systematic study needs to be carried out by ONGC in respect of ground levels near the producing fields with passage of time.

5.9. During the visit of the Committee to the site, the petitioners could not show any direct evidence of land subsidence. However, they showed some location i.e. Yetimeraka, Uppdaguptam(V) and N Kothapeta (V) near Amalapuram where some of the hand pumps and shallow wells, about 3-5 m deep, had become saline where as earlier these were



reported to be of sweet water. These locations were a few km away from the producing wells. Evidently the people were concerned about it.

5.10. Salt water intrusion in isolated wells as an indicator of subsidence is a very weak. The most typical causes for saltwater intrusion are from groundwater extraction or from changes in freshwater flow regimes over time. The large scale changes that have occurred in the area by way of runoff control, canals, etc can have an effect after decades. For instance, hydraulic conductivity in clay soils can also be in the range of cm/year to m/year. In addition, the location of freshwater/saline water interface in estuaries will be a function of freshwater release, which has changed due to water resources projects (even if one ignores year on year differences in runoff, monsoon and non-monsoon flows, tide variations diurnally, between spring and neap, and equinoxes).

5.11. The Committee noted that the problem of salinity in the ground water in the coastal areas has been observed in many places. In one of the published papers (Ref: K. Nageswara Rao, G. Murali Krishna. D. Ramprasad Naik and B. Hema Malini, "Remote Sensing and GIS Applications in the identification of Aquaculture hot spots at village level" published in Journal of the Indian Society of Remote Sensing, Vol.31, No. 2, 2003), the impact of extensive aqua culture in certain areas in this region has been reported. According to this paper, extensive aquaculture and its associated ground water withdrawal has affected the ground water table and led to ingress of sea water in ground water and other environmental impacts.

The Committee is of the view that a detailed study of the problem of salinity in ground waters need to be carried out and remedial measures to be taken. It should be particularly found out whether the salinity problems exist only in the areas near the ONGC fields or other sites also in the delta region.

5.12. In locations where many factors can contribute to subsidence, it is better to measure subsidence directly with topographic levels. Given that subsidence requires accurate measurement, measurement with GPS and DGPS should not be done. Kinematic Global Positioning System (KGPS) is acceptable, while topographic surveys from Survey of India Ground Triangulation Station Bench Mark (GTS BM) may be the most reliable.

5.13. ONGC site representatives informed the Committee that they have not observed any distortion of any pipelines or structures in the field, which leads to the conclusion that no significant land subsidence has taken place.

## 6. Conclusions and Recommendations.

- (i) There is no direct evidence available to the Committee to indicate any land subsidence in the gas field or the adjoining areas in the KG Basin. From geological considerations also, this region does not appear to be prone to significant land subsidence. It is, however, suggested that an expert organization like the Indian School of Mines may be entrusted with a detailed study on existing or likely land subsidence in this region.
- (ii) The problem of underground water getting saline in certain locations has been observed. The exact reason needs to be studied. Some studies have suggested that extensive aquaculture in the region could be a factor. This could also be due to construction of dams in the upstream and erosion of part of the delta. A survey of the whole delta region needs to be carried out.
- (iii) Since land subsidence has been reported & observed in the areas where extensive extraction of underground water, oil &

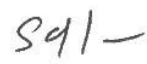
gas or mining in various parts of the world including India (coal mines) has been carried out, this aspect needs to be taken into consideration while taking up any project on underground extraction.


- (iv) Measurement of ground level as baseline data has therefore to be included in the EIA study and periodical monitoring of the level needs to be carried out, during the operational phase.
- (v) In case, geological factors indicate likelihood of land subsidence and consequential impacts, remedial measures need to be planned by the project proponent. Provision of such measures needs to be taken into consideration while evaluating the projects for environmental clearance.


- (vi) A study on the likely impact of offshore extraction of oil /gas, if any, on land close to the coast <sup>in the case of</sup> land subsidence or movement or ground water quality, should be taken up.

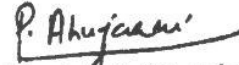
7. The report of the Sub-committee was presented before the Expert Appraisal Committee -2 (Industry) in its meeting held on 23rd October, 2009. The Committee has assessed the report and recommendations made have been accepted by the Committee.

  
R K Garg, Chairman

  
Dr. B. Sengupta, Member

  
Dr Rajat Roy Choudhary, Member

  
Dr. R. Ramesh, Member  
23/10/2009

  
Dr P.L. Ahujai, Member-Convener  
Director, Ministry of Environment and Forests  
Government of India

Place: New Delhi

Date: 23.10.2009

**No.L-11011/7/2008-IA-II (I)**  
**Government of India**  
**Ministry of Environment and Forests**

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 Lodi Road, New Delhi-110003  
 Dated: September 3, 2009

**Sub: Constitution of Sub-Committee in pursuance to the Direction of Hon'ble High Court of Judicature of Andhra Pradesh at Hyderabad(Special Original Jurisdiction) dated 29<sup>th</sup> June, 2009 in respect of Writ Petition No. 13341/08 filed by Krishna Godavari Delta Parirakrasha Samithi, Bhimavaram, West Godavari District in Andhra Pradesh & Others Vs Union of India & Others .**

The Hon'ble High Court of Judicature of Andhra Pradesh at Hyderabad (Special Original Jurisdiction) vide order dated 29<sup>th</sup> June, 2009 has directed to constitute an Expert Appraisal Committee under the provisions of S.O.No.1533(E) dated 14<sup>th</sup> September, 2006 issued under Sub-rule (3) of Rule 5 of Environment (Protection) Rules,1986. A copy of the order dated 29<sup>th</sup> June, 2009 is enclosed.

2. In pursuance to the Directions dated 29<sup>th</sup> June, 2009 of Hon'ble High Court of Judicature of Andhra Pradesh at Hyderabad (Special Original Jurisdiction), the Ministry has decided to constitute and Sub-Committee. The composition of the Committee is as follows:

- |      |  |                 |
|------|--|-----------------|
| i.   | Shri R.K. Garg<br>4, Vikram Jyoti Co-operative society,<br>Opp, Telecom Factory<br>Deonar, Mumbai                | Chairman        |
| ii.  | Shri Rajat Roy Choudhary<br>F-2, Oyster Opera, Gangai Street<br>Kalakshetra Colony,<br>Besant Nagar, Chennai     | Member          |
| iii. | Dr. B Sengupta<br>Former member Secretary, CPCB<br>161, Medha Apartment<br>Mayur Vihar, Phase-1,<br>Delhi-110091 | Member          |
| iv.  | Professor G.S Roonwal<br>C-520, SFS, Sheikh Sarai-I<br>New Delhi- 110017   | Member          |
| v.   | Dr. Mrs. P.L. Ahujarai<br>Ministry of Environment and<br>Forests   | Member-Convener |

3. The Sub-Committee shall:

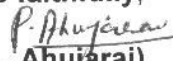
- (i) examine and scrutinize the applications, prefeasibility and EIA reports received by the Ministry for exploration and development drilling activities for oil and gas in the KG basin in Andhra Pradesh and study the aspects of land subsidence.
- (ii) the Committee shall visit selected sites to oil and gas exploration blocks in the KG basin;
- (iii) the Committee shall also consider the contents of the Writ Petition and representation received by the 1<sup>st</sup> respondent from the petitioner within 15 days of the Hon'ble High Court order dated 29<sup>th</sup> June, 2009.
- (iv) the Committee may co-opt additional members , if required.
- (v) the Committee may convene its meeting(s) anywhere in the country.
- (vi) the Committee shall submit the report to the Ministry for assessment by the Expert Appraisal Committee (Industry)-2. The Expert Appraisal Committee-2 shall send its recommendations to the Ministry within two months well in advance of the next hearing before the Hon'ble High Court of Andhra Pradesh in the first week of November, 2009.

4. The Committee may co-opt additional members, if required.

5. The Committee may convene its meeting(s) anywhere in the country. TA/DA and sitting fee of Rs.1000/- for non-official members shall be paid as per norms.

6. This issues with the approval of the IFD vide IFD Dy no. 1974/09/IFD dated 2.09.2009.

Yours faithfully,

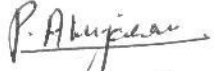
  
(Dr. P.L. Ahujarai)  
Director

**Enclosures as above:**

- i. A copy of Hon'ble Court order dated 29.6.2009.
- ii. A copy of Writ Petition ni.13341/08
- iii. A copy of Representation dated 13.7.2009 from Prof G. Krishna Rao, Petitioner No

**Copy to: -**

1. The Chairman of the Expert Appraisal Committee (Industry)-2 and all the members.
2. The Secretary, Union of India, Petroleum and Natural Gas, Tel Bhavan, New Delhi.
3. The Chief Secretary, Government of Andhra Pradesh, Secretariat Buildings, Saifabad, Hyderabad.
4. The Director General, Directorate-General of Hydrocarbons, C-139, Sector 63, Noida – 201 301.
5. The Member Secretary, Andhra Pradesh Pollution Control Board, Paryavaran Bhavan, Industrial Estate, Sanathnagar, Hyderabad.
6. The Commissioner of Agriculture, State of Andhra Pradesh, Basheer Bagh, Hyderabad.
7. The Oil and Natural Gas Corporation Limited, Jeevan Bharathi, Toer-II, 124, Indira Chowk, New Delhi.
8. The Krishna Godavari Deltala Parirakshana Samithi, Bhimavaram, West Godavari District, Mr. D. Vijay Bhangaru Raju, S/o. Mr. Jagannadha Raju, R/o. Society Buildings, 27-17-17-1/7, Bhimavaram, West Godavari District.
9. Mr. D. Vijay Bhangaru Raju, S/o. Mr. Jagannadha Raju, R/o. Society Buildings, 27-17-17-1/7, Bhimavaram, West Godavari District.
10. Prof. G. Krishna Rao, S/o. late Venkanna, R/o. MVP Colony, Visakhapatnam.
11. CCF, Regional Office , Bangalore
12. The Pay & Accounts Officer, Govt. of India, MoEF, New Delhi-110003
13. The Directorate of Audit, Commerce, Works and Misc-II, AGCR Building, IP Estate, New Delhi.
14. IFD/Budget and Account Section
15. Guard file/Sanction order.

  
(Dr. P.L. Ahujarai)  
Director

**SURVEY RESULT**

<b>Measurement of Ground Elevation (GL) of KG Wells</b>				
<b>SI No.</b>	<b>Well Name</b>	<b>Year of Measurement</b>	<b>Initial Measurement of Ground Level</b>	<b>Measurement of GL during 13-18 Sept. 2008</b>
1	Gopavaram-1	2000	2.620	2.822
2	Kesanapalli-2	1998	1.800	2.213
3	Kesavadasupalem-1	1998	1.800	1.887
4	Kesanapalli West-1	1996	0.180	0.525
5	Mandapeta-1	1988	7.620	7.753
6	Mandapeta-11	1992	6.480	7.043
7	Ponnamanda-3	1998	3.402	3.709
8	Pasarlupudi-19	1994	0.800	1.750
9	Pasarlupudi-4	1988	2.050	2.660

<b>Ground Level (GL) of KG Pillars (Seismic Reference)</b>				
<b>SI No.</b>	<b>Pillars</b>	<b>Year of Measurement</b>	<b>Initial Measurement of Ground Level</b>	<b>Measurement of GL during 13-18 Sept. 2008</b>
1	P-4/AT-A-23/CGG	1997	3.120	3.328
2	P-29/AT-A-33/CGG	1997	4.810	5.706
3	P-11/AT-A-07/CGG	1997	2.670	2.840
4	P-126/GT-ES/2002	2002	7.190	7.636
5	P-134/GT-ES/2002	2002	8.390	8.829



## **SURVEY RESULT**

<b>Elevation data of producing wells of KG Basin</b>				
<b>SI No</b>	<b>Well</b>	<b>Year of Measurement</b>	<b>Observed Elevation by Auto Level</b>	<b>Observed Elevation by Auto Level, 19-21, Oct, 2009</b>
1	Gopavaram-1 (GM-1)	2000	2.620m	2.660m
2	Kesavadasupalem (KV-)	1998	1.800m	1.830m
3	Kesanapalli West-1 (KPW-1)	1996	0.180m	0.240m
4	Ponnamanda-3 (PO-3)	1998	3.402m	3.495m

<b>Ground Level (GL) of KG Pillars (Seismic Reference)</b>				
<b>SI No.</b>	<b>Pillars</b>	<b>Year of Measurement</b>	<b>Initial Measurement of Ground Level</b>	<b>Measurement of GL during 13-18 Sept. 2008</b>
1	P-4/AT-A-23/CGG	1997	3.120m	3.190m
2	P-11/AT-A-07 (CGG)	1997	2.670m	2.675m
3	P22/AT-Y-21(CGG)	1997	2.490m	2.520m
4	P-30/AT A-35 (CGG)	1998	1.510m	1.565m
5	P 48/AT-A-65 (CGG)	1996	1.890m	1.905m
6	P 21/AT-A-65 (CGG)	1996	2.870m	2.880m
7	P9/GT-E5	2002	3.550m	3.635m
8	P13/GT-E5	2002	1.260m	1.315m
9	P 14/AP-93 (ONGC)	1996	4.502m	4.510m
10	P 96/AP-107 (ONGC)	2000	2.685m	2.770m
11	P 8/AP-107 (ONGC)	2000	2.765m	2.905m