Inventory data on the sinkhole occurrences from Proterozoic Cuddapah Basin, India

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Abstract

This data article provides the inventory data on sinkhole occurrences for the first time from Proterozoic Cuddapah Basin, India. Unexpected ground subsidence incidents are taking place with ground breaking sounds and forming in the Cuddapah Basin since 2007 and their frequency increasing from 2015 to 2017 (15 sinkholes over night in and around Buggavanka River). Such incidents are creating panic situations in the general public of this area which was not experienced in this region ever before. It is interesting to note that majority of sinkholes are forming subsequent to heavy rains and sudden recharge, especially in and around Buggavanka and Chitravati River beds. Hence, there is a strong need for the data on the sinkhole occurrences for detailed field investigations in future. Since, sinkhole inventory is a vital and pioneering step in sinkhole hazard analysis, the consistency of sinkhole hazard and vulnerability maps and the efficiency of the mitigation measures chiefly rely on the accuracy, completeness, and fidelity of the sinkhole inventories. Geospatial technologies played a major role in this inventory in terms of data collection, editing and analysis of various thematic maps.

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1. Data

Sinkhole inventory data from parts of Proterozoic Cuddapah Basin, India is given in the Table 1. Fig. 1 depicts the individual sinkhole locations. Fig. 2 gives the glimpse of the field photographs collected by the authors during the survey from various locations viz Chintakommadinne, Pendlimarri, Vempalli revenue mandals from YSR District and Yellanur mandal in Anantapur district from Andhra Pradesh, South India. Fig. 3 provides the long-term precipitation trend. Fig. 4 illustrates the monthly average rainfall from 2005-2017. Fig. 5 shows sinkhole traces captured on the satellite image from Buggavanka River in chintakommadinne mandal. Figs. 6 and 7 present the integrated maps that demonstrate the geological setting along with the sinkhole locations.

2. Experimental design, materials and methods

2.1. Location

The Crescent shaped Proterozoic Cuddapah sedimentary basin extends over a significant part of the southern part of Andhra Pradesh and Telangana States of Southern India. Lithostratigraphically, the Cuddapah basin is divided into Cuddapah super group represented by three sub-basins/groups - Papaghni, Chitravathi, and Nallamalai and Kurnool group; The basin has aggregate thickness of 6–12 km of discontinuous sedimentary pile, which composed of a suite of arenaceous and argillaceous strata with interbedded limestones at top [2,3] in which these sinkholes are occurring. These carbonate rocks are of strategic importance for local communities as they provide the main water source for irrigation and domestic use. Field observations indicate the extensive karstification of the three-carbonate formations present within the Cuddapah sedimentary basin, namely the Vempalle dolomite, the Narji and Koilakuntla limestone, which together cover about 17% of this basin. Due to intensive irrigated agriculture, parts of the limestone aquifers of the Cuddapah sedimentary basin are overexploited [4].
45°85N proterozic sedimentary rocks mainly composed of quartzites, limestones (CaCO₃) and shales of late Archean or early proterozoic (~2000-4000my) crystalline basement, overlain by middle and geological point of view, this area falls in south western part of Proterozoic Cuddapah Basin, consisting habitations from the sites. Majority of the sinkholes formed in this area during 2015 and 2017. In noripalle, Balijapalle, Peddamusalreddy palle, Buggaletipalle and Nagireddy palle are the nearby Papaghni, Nallamalai and Kurnool group of rocks.

2.2. Sinkholes in YSR district

2.2.1. Chintakommadinne mandal

This area lies in Chintakommadinne Revenue Mandal of YSR District of Andhra Pradesh, India. The proposed area lies in Survey of India topographic sheets # 57J/11 on 1:50,000 scale, bounding with latitudes from 14° 20' 41” N to 14° 29' 51"N and longitudes 78° 39’ 1.11”E to 78° 56’ 37.57”E. Nayanoripalle, Balijapalle, Peddamusalreddy palle, Buggaletipalle and Nagireddy palle are the nearby habitations from the sites. Majority of the sinkholes formed in this area during 2015 and 2017. In geological point of view, this area falls in south western part of Proterozoic Cuddapah Basin, consisting of late Archean or early proterozoic (~2000-4000my) crystalline basement, overlain by middle and upper proterozoic sedimentary rocks mainly composed of quartzites, limestones (CaCO₃) and shales of Papaghni, Nallamalai and Kurnool group of rocks.

| Village or area of sinkhole occurrence | Latitude | Longitude | Avg. Diameter (in feet) | Depth (in feet) | Frequency (Year) | Remarks |
|----------------------------------------|----------|-----------|------------------------|----------------|-----------------|---------|
| Musalreddypalle                         | 14°25’32.93”N | 78°50’15.32”E | 28 | 14 | Vegetative stress |
| Bugga kottala                           | 14°18’36.65”N | 78°24’20.34”E | 24 | 10 | 2015 | extended cracks with 96 feet diameter; Unsor ted clay to boulder supported fan |
| Bugga kottala                           | 14°18’36.77”N | 78°24’20.35”E | 15 | 9 | Cluster of sinkholes in Buggavanka Riverbed bed with matrix supported boulder |
| Buggavanka Riverbed                    | 14°25’30.53”N | 78°49’28.72”E | 18 | 9 | 2015 | Opening with water at their base |
| Chagaleru                               | 14°25’31.01”N | 78°49’29.92”E | 24 | 8 | 2017 | Near to Public School overhead tank (20 feet) collapsed into the sinkhole; Calcareous unconsolidated soil bed. |
| Chagaleru                               | 14°25’32.45”N | 78°49’31.05”E | 25 | 10 | 2017 | Deep sinkhole with small opening, gravel bed at base and sand with lime stone leaching at top |
| Kammavaripalle                          | 14°25’30.31”N | 78°49’28.28”E | 29 | 11 | 2017 | Boulder bed, filled with water at the base of sinkhole. |
| Kammavaripalle                          | 14°25’32.80”N | 78°49’28.08”E | 4 | 14 | 2017 | Within Banana plantation adjacent to small stream; clay/loamy soil |
| Chitravathi River Bed                   | 14°24’41.88”N | 78°48’41.18”E | 30 | 10 | 2017 | Crop lands |
| Chitravathi River Bed                   | 14°25’10.17”N | 78°43’33.99”E | 30 | 10 | 2017 | First formed sinkhole; weathered Limestone |
| Chitravathi River Bed                   | 14°35’49.6”N | 77°59’59.5”E | 25 | 15 | 2017 | Opened with big sound |

**Table: 1**

showing the village wise sinkhole locations along with their GPS coordinates and dimensions.
2.2.2. Pendlimarri Mandal

A sinkhole is formed in the agricultural fields of Kammavaripalle Village of Pendlimarri Mandal in 2007 and it is the first known sinkhole occurrence in YSR District. The GPS Coordinates, latitude 14°25′10.02″N, longitude 78°43′34.00″E, falling on SOI toposheet No. 57J11 and this land belongs to B. Venkatasubba Reddy (Survey no: 1224). It was formed as circular depression with deep hole and thereafter is has been widening till to date with a diameter of around 11 m. Weathered Limestone is well exposed in the sinkhole.

2.2.3. Vempalli Mandal

Two huge sinkholes are formed in Buggakottala Village near Vempalli Revenue Mandal, YSR District. The noticed two sinkholes are falling on SOI toposheet # 57J7. The GPS coordinates are latitude 14°18′36.72″N longitude 78°24′20.04″E and 14°18′36.80″N longitude 78°24′20.26″E respectively with one-meter distance in between and extended crack circumference about 35.4 m. Sinkholes are formed in agricultural land adjacent to forest, geomorphologically this location is situated on a pediment alluvial fan.

2.2.4. Vemula Mandal

Couple of sinkholes formed in the agricultural fields of Chagaleru Village in Vemula Revenue Mandal, YSR District. The GPS Coordinates, latitude 14°24′5.20″N, longitude 78°21′46.20″E, Veera Pakkiraiyah’s Cropland and latitude 14°24′4.59″N; longitude 78°21′40.97″E Y. Ramulamma’s Cropland. These two subsidences happened during the heavy rains in the years 2008 and 2015 monsoon periods correspondingly.
Fig. 2. Showing the field photographs collected during the sinkhole inventory from the study area. A- E) Sinkholes formed in and around Buggavanka River form Chintakommadinne mandal; F) Sinkholes in Buggakottala village In Vempalli mandal; G) First formed sinkhole in 2007 near Kammavaripalli in Pendlimarri mandal; H) expansion of sinkhole (G) in 2017; I). Subsidence in Chitravathi River Bed; J) Cluster of 40 bore wells adjacent of Chitravathi river 500 mts away from the subsidence.
2.3. Sinkholes in Anantapur district

2.3.1. Yellanur mandal

The study area is lies in between Goddumarri and Lakshumpalli villages located in Yellanur Revenue mandal of Anantapur district, where sinkholes formed during 2015 and 2017 in Chitravathi river bed. River Chitravathi is the major River in the study area (Fig. 7). GPS coordinates of the Sinkhole locations are 77° 59' 59.5"E and 14° 35' 49.6"N as well as in 14° 35' 42.8"N and 78° 0' 15.4"E. In geological point of view this area falls in North western part of the Proterozoic Cuddapah Basin. The major rock types are Pulivendla quartzites, Tadipatri shales, Lime stones and dolomites belong to Chitravathi group. South
Fig. 5. Google earth historical data showing the location of sinkholes in Buggavanka River beds after the occurrence of sinkholes. (Image on 27-11-2015).

Fig. 6. Integrated geo-sinkhole map showing the various litho units and GPS locations of the sinkholes from YSR district. (red points).
and south western part of the study area subjected to great deformations (fractures, and joints) which resulted denudation hills and structural hills belong to dolomites and quartzite formations of Chitravathi group respectively.

2.4. Methodology

From the Review of literature it is clear that, there is a remarkable raise in investigations on sinkhole and associated damages on a global scale during the last two decades [5,6]. A comprehensive sinkhole
inventory is the primary aspect in Sinkhole hazard analysis and risk assessment. The accuracy and the consistency of sinkhole vulnerability and risk maps greatly rely on the comprehensive and truthfulness of the sinkhole inventory [7]. Hence sinkhole database shall contain the following aspects viz., exact location, magnitude and frequency relationships of sinkholes, Genetic type, Chronology, Activity, including subsidence rates, kinematical behavior (gradual, episodic or mixed) relationship with conditioning and triggering factors [8–14]. Sinkhole inventory with chronological data showed a good correlation with drought periods [15]. In this point of view, a systematic approach has been made to generate the present inventory data. Detailed field surveys carried out in the areas where the sinkholes are distributed and all the location information are collected using hand held Global Positioning System (GPS) and SOI Toposheets No: 57F/14, 57J/11 and 57J/15 on 1:50000 scale along with field information regarding geomorphology, lithology structures and groundwater availability. The collected GPS points imported to ArcGIS to prepare a sinkhole location map. These locations are compared with historic temporal data imagery prior to formation and after the formation of sinkholes in the same area as shown in the Fig. 5. These depressions are absent in the images captured before the sinkhole occurrence. Hence it is clear that these depressions resulted by the formation of sinkholes. Identified depressions are field-checked, and the thematic layers of information viz., Geology map and sinkhole location data allowed the systematic interpretation and preparation of sinkhole inventory data.

Acknowledgements

This work was carried out by the financial support from the DST (Dept. of Science & Technology, New Delhi, India) in the form of INSPIRE Fellowship (IF120393) to the first author.

Transparency document

Transparency document associated with this article can be found in the online version at https://doi.org/10.1016/j.dib.2019.104054.

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