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Present Status of Traditional Rainwater Harvesting Structures in and Around Bikaner City, Rajasthan

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Abstract
The current status of water resources highlights the need for improved water resources management recognizing, measuring and expressing water's worth and incorporating it into decision making, are fundamental to achieving sustainable and equitable water resources management and the sustainable development goals of the United Nation 2030 agenda for sustainable development. Bikaner district is located in the north-west part of Rajasthan and also part of "Thar desert" and desert means drought and water scarcity. The district experiences arid type of climate in the east to extremely arid in the west. Mean annual rainfall of the district 277.55mm whereas normal rainfall is lower than average rainfall and placed at 257.8mm. Atmosphere is generally dry except during the monsoon period. The traditional sources of water in Rajasthan include Nadi, tanka, johad, bandha, sagar, samund and sarover. Out of these traditional water sources lakes, Bawari, Kui, are found in Bikaner. The present status of traditional rainwater harvesting structures in and around Bikaner City is a cause for concern. Many stepwells and talabs that once served as dependable sources of water have been neglected and fallen into disrepair. The lack of regular maintenance and restoration efforts has resulted in siltation, vegetation overgrowth, and the collapse of some structures. Talabs, which were essential for storing rainwater and recharging groundwater reserves, have also suffered from neglect. Many talabs have been filled with silt and garbage, reducing their storage capacity and compromising their ability to meet the water demands of the local communities. Moreover, the water quality in these talabs has deteriorated due to pollution from sewage and industrial waste.The encroachment of catchment areas, the natural landscapes that facilitate rainwater runoff and recharge, has further exacerbated the challenges faced by traditional rainwater harvesting structures. Unplanned urbanization and illegal construction have disrupted the natural flow of rainwater, prevented proper recharge of groundwater and decreased the effectiveness of rainwater harvesting systems. Rainwater harvesting has played a crucial role in addressing water scarcity in arid and semi-arid regions around the world. Bikaner City, located in the Thar Desert of Rajasthan, India, has a rich history of traditional rainwater harvesting structures that have sustained the local communities for centuries. These structures, including stepwells (baoris), talabs (ponds), and catchment areas, have not only provided water for drinking and irrigation but have also served as important cultural and architectural landmarks. The huge pond built in front of Junagarh fort of the city, given the analogy of the SurSagar certainty seems correct. For the first time in Bikaner, ice was formed in this water. Not only this, its water was also used in making Bhujiya and Mishri. It was built by Sursagar ji in 1614.However, the rapid urbanization and changing water management practices in Bikaner City have posed significant challenges to the preservation and functionality of these traditional rainwater harvesting structures. Encroachment, neglect, and inadequate maintenance have resulted in the deterioration of many stepwells and talabs, leading to reduced storage capacity, silt accumulation, and water pollution., Urgent conservation and revitalization efforts are required. These measures should encompass the following: Creating awareness among the local communities, policymakers, and stakeholders about the historical, cultural, and ecological significance of traditional rainwater harvesting structures.

Key words:water bodies, pollution, pesticides, drinking water, traditional practices, water harvesting

Introduction

The current status of water resources highlights the need for improved water resources management recognizing, measuring and expressing water's worth and incorporating it into decision making, are fundamental to achieving sustainable and equitable water resources management and the sustainable development goals of the United Nation 2030 agenda for sustainable development. (UN World Water DevelopmentReport 2021)[1]. India's water crisis is a constant. Although India has 16 percent of the world's population, the country possesses only four percent of the world's freshwater resources. India is water-stressed due to changing weather patterns and repeated droughts. And the worst suffers of this crisis are mostly women.As many as 256 of 700 districts in India have reported „ critical" or overexploited groundwater levels according to the most recent central groundwater board data. This means that getting water in these places has grown more difficult as the water table has dropped. Three access to piped, drinkable water and must rely on unsafe sources. Thar Desert in Rajasthan mostly covers the western part of the state. The Thar Desert lies essentially in the Western Dry Region, and The Thar desert of Rajasthan comprises 13 districts stretching from the Shriganganagar district in North, Hanumangarh, Churu, Bikaner, Nagaur, Jhunjhunu, Sikar, Jodhpur, Jaisalmer, Barmer, Pali, Jalor to Sirohi in South. It can be divided in three subdivisions: (I) the arid western plain zone in the districts of Jaisalmer, Barmer, Bikaner, Churu, and Jodhpur, covering 133074 sq. km), (ii) the transitional plain of inland drainage in Nagaur, Sikar and Jhunjhunun districts (31329 sq. km), and (iii) the transitional plain of Luni basin in Pali and Jalor districts (22951 sq. km). In the north, the Rajasthan irrigated north-western plain zone in the districts of Ganganagar and Hanumangarh (20557 sq. km), is largely a transitional plain between the Thar Desert and the arid Punjab-Haryana plains (Amal Kare, 2017). Desert always has to suffer with water crisis and the below table shows the mean annual rainfall district wise:

Table: 1. Annual rainfall in 12 districts of Rajasthan in Thar Desert

S.No.	District	Mean annual rainfall (MM)
	Arid western plain	
1	Barmer	266.7
2	Jaisalmer	185.3
3	Bikaner	290.6
4	Jodhpur	368.9
5	Churu	365.7
	Canal irrigated north western plain	
6	Ganganagar	255.1
7	Hanumangarh	250.5
	Transitional plains of inland drainage basin	
8	Sikar	467.4
9	Jhunjhunu	402.0
10	Nagaur	327.7
	Transitional plains of luni drainage basin	
11	Pali	426.9
12	Jalor	381.0

The Thar desert is essentially a sand desert, most of whose area consists of dry undulating plains of hardened sand. The remaining region is a large mass of loose sand, forming shifting dunes. The desert environment is inhospitable for plants, animals, and human populations. Yet, it is the most populated desert in the world. In Thar desert, despite an arid environment and adverse living conditions, high population density is recorded. Population density here is 84 persons per sq. km. According to the 2011 census, the human population is 28.15 million and is speculated to reach 41 million by 2031. In the case of livestock, the 2012 census shows a total of 30.18 million (20.5% cattle, 13.0% buffalo, 22.8% sheep, 42.4% goat, 0.9% camel) (Amal Kare, 2017). In Rajasthan, rich floral diversity is growing, with 911 wild species belonging to 780 genera and 154 families (Shetty and Singh 1987–1993; Bhandari 1999). The biodiversity of Rajasthan is unique and diverse because of its physiographic feature. In Rajasthan different geographical conditions provide extreme habitat for a wide range of flora, including bryophytes, pteridophytes, alone gymnosperm – *Ephedra foliata*, and angiosperms including halophytes, hydrophytes, and xerophytes. Xerophytic plants are considered the key component of desert verdure. It needs less amount of water to grow than other floras. This is evidenced by species richness, genetic variation, and biological diversity, which exist in Thar. There are documented about 3000 floral and faunal species in the state (Sharma and Upadhyay 2014). There are over 900 species of plants found in Thar most of which are endemic to this Desert, while a few exotic species like *Prosopis juliflora*are predominant in different habitats. Of over 900 species, some 85 species of grasses are native to Thar Desert including 'Sewan' (*Lasiurus sindicus*) and 'Dhaman' (*Cenchrus ciliaris*). Thar Desert standout amongst the most intensely populated (human and domesticated animals) deserts of the world, which result, in biotic interruption exert burden on 84 economically imperative plant species, because of which 31 species have turned out to be either vulnerable or imperiled. Of these, 17species and 8 botanical assortments are endemic to the Great Indian Thar Desert (Singh, 2004).The characteristics of the habitat play a very important role in transforming the fauna ofthe surrounding. The creatures transform themselves in the adverse temperature and usually smaller animals commonly adopt nocturnal and subterranean life modes, also in the Thar Desert (Prakash 1964). In the desert the most encountered difficulty is a scarcity of water and animals satisfy utilizing their sustenance (vegetation or other animals) e.g Gerbils, Squirrel, Porcupine (Prakash 1964). Bikaner district is located in the north-west part of Rajasthan and also part of „Thar desert" and desert means drought and water scarcity. The district experiences arid type of climate in the east to extremely arid in the west. Mean annual rainfall of the district 277.55mm whereas normal rainfall is lower than average rainfall and placed at 257.8mm. Atmosphere is generally dry except during the monsoon period. The traditional sources of water in Rajasthan include Nadi, tanka, johad , bandha, sagar, samund and sarover. Out of these traditional water sources lakes, Bawari, Kui, are found in Bikaner. Bikaner still has varieties of water bodies like wells,pondsand step well, Which is depending on rain water. To keep the water source safe, our ancestors had built temples around the same as a result the belief of the people will not make that holy place dirty by which the water of that place can also be saved from getting spoiled. In the past the water in the water bodies of Bikaner was full and clean that was potable water. But right now, the condition of these sources is pathetic. They are facing many problems of encroachment, unwanted development, ignorance etc.

Study area

Location: Bikaner is situated in the North-Western part of Rajasthan which is a central part of Great Indian Desert. Its geographical location is 27°11' to 29°3' North and 71°54' to 74°12' East. It is bounded in north by Ganganagar District, east by Hanumangarh and Churu Districts, south by Nagaur and Jodhpur Districts and in the west by Jaisalmer District and shares 168 km international border with Pakistan. The geographical area of the district is 30247 Sq.km. which is about 8.8 % of the state's total area and possess second place after Jaisalmer. It is divided in the eight subdivisions: Bikaner, Lunkaransar, Kolayat, Nokha, Khajuwala, Pugal, Chhatargarh&Dungargarh.

Climate of Bikaner: Bikaner is in the middle of the Thar desert and has a hot desertic climate (Köppen climate classification *BWh*) with extreme temperature and low rainfall. The annual rainfall of Bikaner is 290.6 m.m. and the rainfall varies from 260–440 millimeters (10–17 inches). In summer temperature rises till 50°C, and during the winter it touches to freezing point. Variation

in temperature is a specific criterion of environment of Bikaner. In the summer temperature varies from 28–53.5 °C and in the winter is noted below freezing point and varies in the range of −4–23.2 °C. high speed wind called by the name “Loo” during summer and “Seetlaher” during winter.

Fauna & Flora of Bikaner:

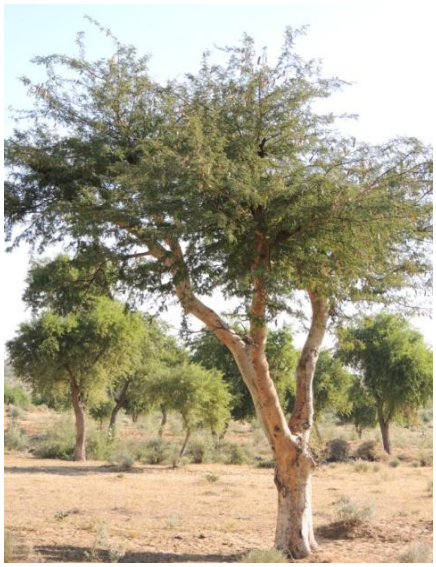
The area is mainly dominated by arid vegetation of *Salvodoraoleiodies, Prosopis cineraria, Prosopis juliflora, Acacia jacquemontii, Acacia nilotica, Acacia Senegal,* shrubs of *Ziziphus nummularia, calligonumpolygonoides, Leptadeniapyrotechnica, Calotropis procera,* and grasses like *Lasiurus scindicus, Dactylocteniumsindicum, Cenchrus setigerus, Cenchrus ciliaris, Eragrostis minor,* etc. These CPRs are also home for many desert dwelling animals like Indian gazelle *Gazella bennettii*, Desert cat *Felis silvestrisornata*, Desert fox *Vulpes vulpespusilla*, Jungle cat *Felis chaus*, Black-napped hare *Lepus nigricollis*, Wild boar *Sus scrofa cristatus*, Indian jackal *Canis aureus indicus*, and Desert gerbils *Merioneshurrianae*in mammals. Monitor lizard *Varanus bengalensis*, Indian Desert monitor lizard *Varanus griseus* and Spiny-tailed Lizard *Saarahardwickii*Black cobra *Najanaja*, Saw-scaled viper *Echiscarinatus*and common krait *Bungarus caeruleus* are some major reptiles of the study area.The most common tree found in the Bikaner district is Khejri (*Prosopis cineraria*), Rohira (*Tecomellaundulata*), Ber (*Ziziphus jujube*), Jhal or Pilu (*Salvadoraoleoides*) and Ker (*Capparis aphaila*) etc. Among the shrubs found in the region, mention may be made of Aak (*Calotropis procera*), JharBeri (*Ziziphus nummularia*), Phog (*Caligonumpolygonoides*), and Ker (*Capparis decidua*) while in some scattered pockets of *Haloxylon* are also available in sufficient quantity. The grass community which is prevalent in the district is Lat-Jeera (*Achyranthes repens*), Bathuwa (*Chenopodium album*), Motha (*Cyperus rotundus*), Dhamaso (*Fagoniacretica*), Hiran-Chabo (*Farsetiahamiltonii*), Bekar (*Indigofera cordifolia*), Lambio-Bekario (*Indigofera linifolia*), Bur-Ghas (*Tragus biflorus*), Gokharu (*Tribulus terrestris*), Ashwagandha (*Withaniasominifera*), Dudheli (*Euphorbia hirta*), Chidiyaro Khet (*Mollugocerviana*), Lamp (*Aristida funiculata*), Bharut (*Cenchrus biflorus*), Dhaman (*Cenchrus ciliaris*), Bharbhutyo (*Cenchrus setigerus*), Thor (*Euphorbia granulats*) are important herbs of the district and most part can be seen on the stones and sandy regions .

Khejda (*Prosopis spicigera*)

Kejdi (*Prosopis cineraria*)

Ker (*Capparis decidua*)

Desi Banwal(*Acacia nilotica*)



Kumth (*Acacia Senegal*)

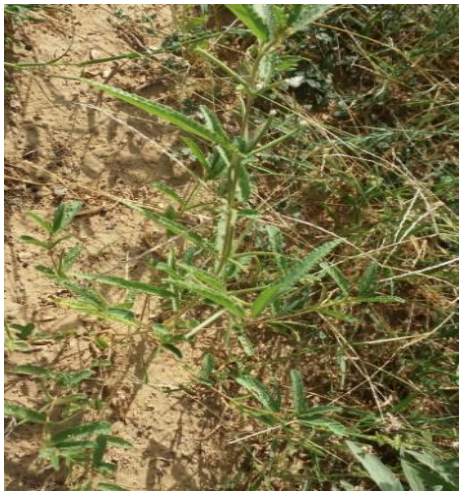
Jaal (*Salvadoraoleoides*)

Plate 1: Trees of study area

Jherniya(*Dactylocteniumaegyptium*)

Sankhpuspi (*Convolvulus deserti*)

Bharut (*Cenchrus setigerus*)



Aadi bekar(*Indigofera linnaei*)

Kaga roti (*Corchorus trilocularis*)

Bekar (*Indigofera linifolia*)

Plate2 : Grass of study area

Gazella bennettii

Boselaphustragocamelus

Lepus nigricollis

Canis aureus indicus

Sus scrofa cristatus

Vulpes vulpespusilla

Plate3: Mammals of study area

Results and Discussion:

Out of all the wells, the maximum water came from Chautina well. It was called Chautina well because water came from all four directions. Water from these wells was pumped into large tanks and supplied inside the city by putting leather belts on camels. In the year 1944, the former Raja Sadul singh established „Sadul water supple and rural reconstruction fund" for the state of Bikaner with 40 lakh rupees. Out of this, Rs 25 lakh was kept for the arrangement of drinking water in capital and Sri Ganganagar and for the disposal of dirty water. Rs 15 lakh was distributed over five years. From these, for the improvement reconstruction and advancement of villages and 1 lakh rupees were kept for wells, ponds and bunds in case of emergency. At that time, leases of wells were also issued in the name of a particular person. Excavation were carried out at jaillwell up to 1710 feet. In the year 1807, water distribution in Bikaner Anand sagar(currently new well), Pooran Bai Well, Mohton"s well, Pratapmal well, Benishwar well, Brijnathvyas well, Raghunath well, Songiri well (of songiri Raja Zorawar Singh ji) This well was constructed in the name of wife and brother used to be from the well. There was a time when 108 wells and tube well in Bikaner used to quench the thirst of the city. Water did not come one time, but used to run for twenty-four hours. There was water when you opened the tap. On the contrary, today it is worrying that if the canal is closed for 85 days, then water will be available once in two days. If the top officials of the water supply department are to be believed, then today the city would not

have to worry about drinking water if the traditional means were left in place. 30 year ago there was no such situation in Bikaner. Actually, then a large part of the city was getting water only through traditional means. Then Jailwell alone was supplying 20 percent on Bikaner‟s supply. Apart from this, water was supplied in urban and rural areas from twenty wells including Phool Bai well, Songiri well, Ghairulal well, Ballabha well, Benisar well. There were also a large number of tube wells in the villages. Canal water was reaching very little part. On the contrary , today 100 percent water supply in Bikaner is being done from Indira Gandhi Canal. At the time when Bikaner was getting water from traditional means, then it was exploited fiercely. Now most of the wells in Bikaner have dried up and there is no water due to excess water extraction. Most have been closed except Phoolbai well, which was bore several times but no water came. Recently, the water supply department has started the exercise of starting some wells of Bikaner. In which Benisar well, Gherulal well and Ballabha well are being recharged again. According to the experts of the water supply department, there is not much chance of water coming out now. Some water may come out from Ghairulal and Ballabha wells, while the water level in other wells has reached more than a hundred feet water below. It is not necessary that the water should be potable there as well.

Table.2: Construction time of various pools and ponds in Bikaner city

Talab or Tallaiya	Construction Time
1. Sansolav	1572
2. Phoolnathsagar	1777
3. Dharnidhar	1776
4. Raghunath sagar	1821
5. Modi kuan	1937
6. Harsolav	1688
7. Shivbari	N.A
8. Sursagar	1614
9. Devikundsagar	N.A
10. Nath sagar	N.A
11. Kalyan sagar	1630
12. Mahanand talai	1767
13. Vishwakarma sagar	1925

Table.3: Present Status of the various water bodies

S No.	Pond	Type of water body	Catchment area	Present Status
1.	Chhimpolai	Talaab	13	Dried, catchment area encroached
2.	Raghunath sagar	Talaab	6	Dried, catchment area encroached
3.	Sansolav	Talaab	19	Dried
4.	Jamnolaitalai	Talaab	6	Dried, catchment area encroached
5.	Nathsagar	Pond	7	Urbanisation ruined the water body
6.	Boharolaitalai	Talaab	5	Dried, catchment area encroached
7.	Navalpuri	Pond	11	Dried, catchment area encroached
8.	Harsolav	Talaab	14	Polluted Water
9.	Farsolai	Pond	14	Dried, catchment area encroached
10.	Peer talai	Talaab	16	Half of the catchment area encroached
11.	Darjiyon ki talai	Pond	4	Dried, catchment area encroached
12.	Nayiyon ki talai (gangolav)	Pond	3	Dried, catchment area encroached
13.	Raghunath sagar (phoolnath)	Talaab	13	Half of the catchment area encroached
14.	Kaanolai	Talaab	4	Dried, catchment area encroached
15.	Ghadsisar	Talaab	17	Half of the catchment area encroached
16.	Kalyansagar	Talaab	10	Dried, catchment area encroached
17.	Devikundsagar	Talaab	7	Polluted water
18.	Phoolbaikuan	Kuan	NA	Potable water
19.	Modi kuan	Kuan	NA	Closed
20.	Phoolnathsagar	Bawari	16	Polluted water
21.	Sursagar	Pond	NA	Polluted water
22.	Chautinakuan	Kuan	NA	Potable water
23.	Jail well	kuan	NA	Potable water

24.	*Karnisagar*	*kuan*	*NA*	*Potable water*

It is important to talk about a well which is 100-year-old well which is built in the supervision/ leadership of Phoolbai to get relief from the situation of famine. According to the local people water of this well has a miraculous property, from which many diseases are removed. This is the only well in Bikaner whose water is still being used for drinking purpose. Due to less depth of water some of the water bodies or wells the local people gotthe bore well drilling done at their own . After drilling water level rise up and water becomes potable. After some time, the water depth worked again and once again drilling was done without any help of government. The neighbor installed taps on all side of well and a motor too. people of both Hindu and Muslim community live in this area. The people of Muslim community consider the water of this well to be better for them. The people of the neighborhood have done very good work for this well, due to which the water of this well is still drinkable. From the table no -2 its evident that water from all the wells is potable in the presentscenarioand still in use by the common public except one exception that is modikuan in Gopeshwar Basti. This well is closed by the local community due to a suicide case happened in the well.The water of Phoolnathsagarstepwell is not potable at all just because of many microorganisms and mosquito larva have grown in this water.The water of this stepwell is used only in the mahadev temple near it for worshipping. Water of this stepwell is also used to give water to plants and its worthy to note this is only step well in the Bikaner city. Another reason which makes this step well unusable is because the enchantment area of this water body is being used by the municipal cooperation of Bikaner as a dumping yard for the solid waste of the city. During the rainy season all this solid waste get drifted towards the step well making it polluted and unusable.Theponds and talaabhave become nearly redundant and even if few are left that is just because of religious activities and temples around these water bodies. In most of the talaab and ponds, there is an accumulation of algae on the upper surface, light cannot pass through the water due to which the plants present inside the water are not able to complete the process of photosynthesis. Due to less dissolved oxygen under water life possibility is zero.So,this can be interpreted that it is an example of bad ecosystem or ruined ecosystem. To save these water bodies from the daily activities of the people, the natives have built a well around this pond. I was also observed that some people secrete excreta in the empty space around this pond. Therefore, boundaries have been made to prevent mixing of sewage into the water. The water filling of such water bodies is totally dependent on rain.

Another aspect which has been reported by Sharma .M, 2021 that organochlorine pesticides (OCPs) were found in the drinking water samples and milk samples from Bikaner city of Rajasthan, India, and it was found that mostly all samples have OCPs residues and many of them are statistically significant $P< .05$ and $P< .01$. This shows that how these xenobiotics have contaminated our Mother Nature and now faunal diversity is facing danger of existence and faunal diversity is not staying away from this potential danger. More scary studies have indicated that we have largely over looked the darker side of these chemicals as OCPs are reported to be carcinogenic (Mathur et al, 2002 & Ingber et al 2013) mutagenic (Ingber et al 2013 &Yaduvanshi et al 2012) teratogenic (Yaduvanshi et al 2012 & ATSDR. Atlanta, GA.1994) immunosuppressive (Repetto. R & Baliga. S.S, 1997 &Corsinia et al, 2003) create endocrine dysfunction such as hypothyroidism or high estrogenic activity (Dewailly et al 2000 & Rathore et al, 2002) disturb reproductive processes (Pant et al ,2007 &Tiemann.U. 2008) growth depressants (Colborn et al, 1993 & Mercier. M, 1981) induces several psychogenic and neurogenic abnormalities in adult stages (Mactutus& Tilson, 1986 & Van Wendel de Jood et al,2001) and are associated with abortions, premature deliveries, still births and infants with low birth weights (Saxena et al, 1981; Saxena et al, 1980; Tyagi et al 2015; Chen. Q et al 2014 & Sharma & Bhatnagar, 1996). OCPs have been in use in India nearly for a half century now. Even after having clear cut evidence suggesting that these chemicals have the ability to eliminate entire species from the planet, the annual consumption of pesticides in India is about 85,000 tons of which OCPs comprise the bulk (India Environment Portal Knowledge for change, 30/10/1998.). Therefore, today OCPs are perhaps the most ubiquitous of the potentially harmful chemicals encountered in the environment

and are still widely detected in humans despite the considerable decline in environmental concentrations (Dewan et al. 2003). This kind of environmental Contamination with organochlorine pesticides (OCPs) has also been reported by Sharma and her coworkers in 1996 from Jaipur City. She reported contamination of human samples like mothers' blood, cord blood, placenta and mothers' milk with OCPs. Presence of pesticides with OCPs shows that how these xenobiotics have contaminated our Mother Nature and now faunal diversity is facing danger of existence and animals are not staying away from this potential danger. It can be concluded that the magnitude of pollution is quantitatively enough to contaminate the food and environment and reaching out to all faunal diversity. It can be concluded that the magnitude of pollution is quantitatively enough to contaminate the food and environment and the pesticides reach the human body through various sources mainly by absorption form the gastrointestinal tract through contaminated food chain, are circulated in blood, stored milk and secreted during lactation resulting in sufficient neonatal intake. The battle against the harmful insects would be much less costly and more efficient, and the problem of contamination of the environment by toxic materials would be vastly reduced, if insect activities are controlled by natural means. The use of pest-specific predators; parasites or pathogens; sterilization of insects with the help of radiations; trapping insects using insect attractants like pheromones; use of juvenile hormones or hormone inhibitors may therefore be suggested as alternate ways of pest control (Sharma, 1996; 2021a; 2021b;2021c;2021d), Sharma, M. & Bhatnagar, P, 1996 & 2017; Sharma. M and Singh. (2021).

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