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Research Article

Health Impact Assessment – A Retrospective Study for Prospective Approach in Madhya Pradesh, India

Anushrita[1], Nagpal BN[1], Srivastava Aruna[1], Saxena Rekha[1]*, Kapoor Neera[2], Chand SK[3], Sanjeev Kumar Gupta[1], Dash AP[1], Dua VK[1] and Valecha Neena[1]

[1]National Institute of Malaria Research (ICMR), India

[2]Indira Gandhi National Open University, India

[3]National Institute of Malaria Research Centre Field Unit, India

***Corresponding author:** Saxena Rekha, GIS, Taxonomy and other VBD Division, National Institute of Malaria Research, Sector-8, Dwarka, New Delhi, 110077, India, Tel: 01125307326; Email: saxenar@icmr.org.in

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Abstract

Dams and Irrigation channels have long been a topic of serious debate, principally because of their repercussions over human health despite their many promising benefits on stakeholders. Construction activities continue for many years which further change the micro climatic condition of surrounding areas. This rapid change of climatic condition and vector dynamics bring a lot of challenges to control strategies of respective authorities. Indira Sagar (ISP) and Omkareshwar (OSP) dams are two major dam projects in Madhya Pradesh (MP), India and have created many changes at a very large scale in various domains of health. Health Impact Assessment (HIA) is the tool to bring all such complexities at a common platform and to provide decision-makers a set of evidence-based recommendations about the proposal. In view of this, Narmada Valley Development Authority (NVDA) of MP state provided a project along with funding to National Institute of Malaria Research (NIMR), Delhi to conduct a retrospective HIA study of sentinel villages, rehabilitation and resettlement (RR) colonies along with temporary labor settlements of ISP and OSP dam project area starting from 2004 onwards (2004-2013) with especial focus on malaria along with other VBDs. Entomological and epidemiological surveys were conducted thrice a year in three seasons namely pre-monsoon, monsoon and post-monsoon seasons. Baseline surveys were done during 2004-05 to analyze the situation. After 2005, various situation specific mitigation measures were suggested to the state health authorities, NVDA and NHDC based on Integrated Vector Management (IVM) approach and were implemented simultaneously to bring down the disease incidence and the impact was studied during subsequent years. During the initial years man hour density of *An culicifacies* (major rural vector) for the selected villages was observed to be very high (2-278). After intervention it was observed to be as low as (0-9). Density of other vector species viz *Culex quinquefasciatus* and *Aedes aegypti* could also be reduced to zero in later phases of studies. The impact of interventions for this study could be seen on the number of malaria cases in study areas. The malaria cases were also high in 2004 (299) which reduced to 2 cases due to stakeholder's participation and early detection and prompt treatment. The current study brings for the first time a retrospective health impact assessment of a dam impoundment with respect to the mosquito borne diseases especially malaria.

Keywords: Health impact assessment; Malaria; Dams; Irrigation; Canals

Introduction

During the post world war era, a revolution for development of various sectors came into existence throughout the globe which was intended towards technical advancements. All possible avenues were explored to utilize available resources of which dam construction to harness water resources was one of the interests. To meet the requirements of irrigation, drinking water, providing electric supply to the remote areas and nourish the unfertile areas, proposal of creating large dams on big rivers and its tributaries came into existence, so that the hydropower could be utilized for the development of various areas. Development of Tennessee Valley in US is one of the greatest examples of such ambitious projects [1]. The main course of Tennessee River was proposed for construction of 9 dams and numerous others on its tributaries [2,3]. In Africa, effective planning of water resources was proposed to curb the widespread risk of hunger [4]. For most countries, dams are a crucial part of economic and social development and, as such, they aim to achieve important socio-economic development objectives; consequently an estimated 40,000 large and 800,000 small dams have been constructed worldwide till date covering 272 million hectares of land for irrigation and inundating an area of more than 400,000 km^2 globally [5,6]. In a developing country like India, rich in its water resources, various techniques were proposed to utilize the water as a potential source for economic growth and in a major push, approximately 4846 major dams were reported to be constructed till 2012 and 347 large dams are under construction [7].

Large dams create various potential breeding sites for Vector Borne Diseases (VBDs) viz. malaria, filarial, Dengue/Dengue Haemorrhagic Fever (DH/DHF), Japanese Encephalitis (JE) Onchocerciasis and Dracunculosis etc and amongst these, malaria takes a large share in cumulative incidence [8]. A study done on Gilgel-Gibe hydroelectric dam in Ethiopia reported the children living in close proximity of

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the reservoir at higher risk of malaria as compared to those living in faraway places [9]. Surroundings of Manso hydropower plant reservoir in central Brazil was reported to be highly favorable for breeding of *Anopheles darlingi* which was found responsible for transmission of malaria in region [10]. River bed pools of major dams in Sri Lanka are reported to be supporting breeding of 10 major potential vector species i.e. *An barbirostris, An culicifacies, An jamesii, An maculatus, An nigerrimus, An peditaeniatus, An subpictus, An tessellates, An vagus,* and *An varuna* [11]. Bargi dam construction in MP, India resulted in more than 32 fold increase in Slide *Falciparum* Rate (SFR) in Narayanganj PHC of Mandla district during 1979-1997. Mandla district as a whole recorded double of mean Slide Positivity Rate (SPR) and SFR during the same period [12]. The irrigation channels of the dams are of further concern to health authorities as it takes time to get them constructed and in the meantime they provide ample breeding sites to vector mosquitoes. In a study over effect of irrigation canals on malaria in Orissa state of India , it was revealed that areas around Canals Under Construction (CUC), SPR was reported 24.54% as compared to Canal With Water (CWW) where SPR was 18.82 % and average API was 7.66 and 22.6 for CWW and CUC respectively [13]. Introduction of irrigation channels from Basavasagar and Almatti dams in Karnatka made four districts in northern Karnatka endemic to malaria and despite establishing a control unit it could not be constrained [14]. Despite the precautionary measures taken after increased malaria incidence due to Ganges canal in 1854, in 1920 construction of Sarda Canal in 'Terai' regions of United Provinces of Oudh, India encompassing 12 districts witnessed a sudden upsurge of malaria cases [15]. The construction of earth 'bunds' (embankments) was the main cause of water stagnation in various places of the 'Terai' region.

World Health Organization (WHO) has long been concerned about the effects of dams and other water resources development projects on human health and has catalogued their health impacts, particularly on a range of communicable tropical diseases [16]. This has further been made evident in a report by World Bank which states- "the existing threat from malaria within the [irrigation] area is serious, and the project has not built with 'appropriate safeguards'" [17]. This favours the existence of such 'appropriate safeguards' that could be applied and should be continued if the project aims to be beneficial for all stakeholders. These safeguards are designed and put into a structured framework after assessing the minute details and several other aspects of the project. This is collectively known as HIA of the proposed project for which the government is much concerned as health of the affected community becomes the highest priority [18]. The purpose of HIA is to provide decision-makers with a set of evidence-based recommendations about the proposal. The decision-makers can then decide to accept, reject or amend the proposal, with the knowledge of the best available evidence before them. Evidence used in an HIA can be both qualitative and quantitative, and each is valuable in due course of time. HIA can be done with a concurrent, retrospective and prospective view. Retrospective studies are conducted after the completion of a project nevertheless they are required for creating a base of all future projects to cut down the cost incurred on human health. HIA of Konkan Railways is one of the examples of retrospective studies done by NIMR during 2007 for complete elimination of VBD outbreaks [19].

ISP and OSP dam projects were constructed by the government of MP, India for the purpose of increasing electric power supply by creating large hydropower plants along with enhancing the economic growth of the population of the state by providing irrigation. After completion, the pros and cons of the dam projects were analyzed by the MP council of science and technology which had predicted "the incidence of malaria, filariasis, cholera, gastroenteritis, viral encephalitis, goitre and some other water borne diseases are likely to increase," due to the SSD (Sardar Sarovar Dam) and NSD (Narmada Sagar Dam) [20]. In view of this, NVDA of MP state provided a project along with funding to NIMR, Delhi to conduct a retrospective HIA study of sentinel villages, RR colonies along with temporary labor settlements of ISP and OSP dam project area starting from 2004 onwards (2004-2013) with especial focus on malaria along with other VBDs.

Materials and Methods

Study site

Villages falling into the periphery of 3 kms of dam impoundments of ISP and OSP and canal areas were selected based on flight range of mosquitoes i.e. approximately 3 kms [21]. On the basis of submergence, entire study area was divided into two broad categories i.e. totally submerged and partially submerged villages. The communities coming under totally submerged villages had to be rehabilitated to a new places for their livelihood. Complete inundation of villages was not a potential problem with reference to vector borne diseases. The greater risks were imposed to partially submerged villages. For partially submerged villages, most affected people were decided to be relocated to the newly established RR colonies made by state government with the basic facilities like drinking water, school, health centre, panchayat bhawan etc. provided by NHDC. The canals emerging from ISP and OSP reservoirs were partially built and were being further constructed during the study period. A total of 32 villages falling in 7 districts namely Khandwa, Khargone, Dewas, Jhabua, Harda, Badwani of MP covering two dam projects were selected for the study. These villages were located at the periphery of reservoirs, at the dam sites and at the canal lines. Further 18 RR colonies were also assessed for the presence of breeding sites (if any) to avoid future outbreaks. Labor colonies were the temporary settlements nearby the construction sites and were moving colonies for earning their livelihood. Six labor colonies were also taken into consideration as most of the working labors came from the endemic areas like Andhra Pradesh and Orissa.

Frequency of surveys

The surveys for HIA were divided on the basis of seasonal transmission throughout the year. The visits were conducted to the study area three times a year i.e. Pre-monsoon (Feb-May), Monsoon (June-Sep) and Post-monsoon (Oct-Jan). For the period of 2004-2013, thirty surveys were conducted. In each survey, a team of six to seven members visited the selected areas and collected entomological and epidemiological data. All study villages, RR Colonies and temporary labor settlements were covered for each survey for entire study duration i.e. 2004-2013. The inaccessible remote areas were covered by possible convenient mode like boats or punt.

Entomological data collection

Man hour density: For all the selected 32 villages, 18 RR and

6 labour colonies, mosquitoes were collected in every survey for three seasons i.e. Pre-monsoon (March), Monsoon (July) and Post Monsoon (Oct). Indoor resting mosquito collections were done during early morning (6-10 am) by hand catch method with the help of suction tube and torch. To avoid any bias, 4 houses were fixed in each study village and 4 were selected randomly. These houses were covered in each survey and mosquitoes collected were brought to base laboratory for identification. The mosquitoes were identified following the standard identification key [21,22] and Man Hour Density (MHD) was calculated as per following formula-

$$MHD = N \times 60/T \times P$$

where, N= No. of mosquitoes collected; T = Time spent in minute; P = No. of persons involved in collections. Average of the collected mosquitoes was taken to analyze overall trend during 2004-13.

Space spray collection (total catch): In space spray collection, a room of standard size dimension which is approximately 4x5 m, was selected and all the outlets were closed. The whole area inside was covered with white bed-sheets and an aerosol insecticide under brand name Hit was sprayed in the room and it is left for 10-15 minutes. After that, all bed-sheets were taken out carefully and the mosquito species were collected on a petri-dish in wet cotton. They were also analyzed for different gravid conditions i.e. gravid, semi-gravid, half-fed and fully-fed and after segregation room densities were calculated. Average of the collected mosquitoes was taken to analyze overall trend during 2004-13.

Larval breeding habitat: Mosquito breeding survey was carried out by the standard WHO methods using bowls and dipper from water bodies and with hand net from wells. All water bodies created due to canal and dam seepage namely ditches, pools and pits etc, man-made holes at construction sites, unused curing tanks, pipes, drums, bufflow wallows, hoof prints, margins of reservoir, and domestic containers were checked for larval breeding. The shallow water bodies were checked using a white bowl and more than 1 m of depth was checked using dipper with a handle of 1 meter making a 45^0 angle from the surface. At least 10 dips were taken from each water body and number of larvae were pooled and counted. All the larvae and pupae collected were brought to the field laboratory and emergence of species from different breeding sites was noted. During the survey, the available peri-domestic and intra-domestic breeding growths were checked in the villages.

For breeding of *Aedes* larvae, peri-domestic containers were checked and percentage positivity in terms of container index was calculated with the following formula-

Container Index (CI) = Positive Containers/Containers Inspected x 100

It is important to note that *Aedes* specific larval surveys were done till 2010 only.

Epidemiological data collection

Microscopy and rapid diagnosis: Cross sectional survey and active surveillance were carried out in the villages. Blood slides from finger pricking of fever cases available in the villages were made. The blood smears were prepared and labeled in the field. These slides were carried to the NIMR, Delhi laboratory and were fixed in methanol and stained with Jaswant Singh Bhattacharjee (JSB I and JSB II) stain. The stained slides were observed under 100 x magnification under oil immersion lens of a compound microscope for detection of malaria parasite. Approximately 100 microscopic fields per slide were examined for confirmation of both falciparum and vivax erythrocytic stages.

Plasmodium falciparum(Pf) & *Plasmodium vivax(Pv)* cases were detected with the help of rapid diagnostic kit for the early diagnosis and treatment of patients positive for *Pf*. The kit used in this survey comes under the trade name Falcivax for the detection of *Pf/Pv* utilizing the principle of immunochromatography. To start the test, first of all it is brought to the room temperature and then finger of the patient is pricked to take out blood on the loop provided with kit and the blood is blotted on the sample pad in the sample port A. Immediately four drops of clearing buffer are dispensed into port 'B', by holding the plastic dropper bottle vertically. After 15 minutes readings are taken. If only one pink-purple band appears at control window 'C', the test is considered as negative, if in addition to control band one other bands also appear the test is considered to be positive for either or both the plasmodium species. All the positive cases during active surveillance were given radical treatment as per National Vector Borne Disease Control Program (NVBDCP) of India guidelines.

Cytologic identification for sibling species: Sibling species are known to be very similar in appearance, behavior and other characteristics but they are reproductively isolated. This could also be inferred as pairs of genetically related species which could not be differentiated morphologically but while they may interbreed their offspring cannot reproduce. *An culicifacies* comprises of 5 sibling species namely A & B [23] (Green & Miles 1980), C [24] (Subbarao *et al*, 1983), D [25] (Vasantha *et al* 1991) and E [26] (Kar *et al*, 1999). In a study done by Sharma et al in 2006 these sibling species have shown differences in various characteristics and also in Human Blood Index and sporozoite rate [27]. Consequently, for targeted intervention, studying the prevalence of sibling species in the study areas becomes very important. Therefore to study the prevalence of sibling species, samples of mosquitoes from 4 randomly selected villages namely Tikarighat, Gujjarkhedi, Chandel, Chikdhaliya, and one Sarlaya RR, were collected. From adult female mosquitoes at the half-gravid stage (Christopher's late stage III), ovaries were extracted and preserved in Carnoy's fixative (1:3 glacial acetic acids: methanol). The rest of the body was preserved in isopropanol for DNA extraction. The ovaries and the rest of the body of a given mosquito were assigned identical labels. Care was taken to dissect out the abdomen in the case of blood-fed females before DNA extraction to avoid mosquito genomic contamination with vertebrate DNA from the blood. The ovaries of individual mosquitoes were processed for polytene chromosome examination following Green and Hunt31 and were identified using the paracentric inversions on the X-chromosome and chromosome arm 2.

Implementation of mitigation measures: To study the impact of suggested mitigation measure, entire study was divided into two major slots i.e. before intervention (2004-2005) and after intervention (2006-2013).

The first slot, 2004-05 was the period of observation and baseline surveys were done to scope and analyze the situation. During this

Table 1: MHD of vectors during 2004-2013.

	Malaria		Filaria	JE	Dengue
	An. culicifacies	*An. stephensi*	*Cx. quinquefasciatus*	*Cx. vishnui*	*Ae. aegypti*
Before Intervention					
2004	2-278	1-8	11-377	0-11	0-17
2005	4-313	2-9	18-401	0-12	0-27
After Intervention					
2006	1-107	0-5	4-215	0-2	0-4
2007	0-21	0-2	3-103	0-1	0-1
2008	0-22	0-25.5	0-21	0-1	0-2
2009	1-28	0	0-5	0	0
2010	0-13	0	0-4	0	0
2011	0-12	0	0-6	0	0
2012	0-11	0	0-3	0	0
2013	0-9	0	0-5	0	0-4

period no intervention towards control was done. After 2005, various situation specific mitigation measures were suggested to the state health authorities, NVDA and NHDC based on Integrated Vector Management (IVM) approach and were implemented simultaneously to bring down the disease incidence and the impact was studied during subsequent years. Following measures were carried out in IVM mode : - 1) de-weeding of canals; 2) release of larvivorus fishes in tanks, ponds and wells; 3) canal lining with plastic sheets to avoid seepages; 4) source reduction by involving community ; 5) spray of pyrethroids and DDT in problematic villages/RR Centers; 6) cleaning and oiling of drains on monthly basis; 7) fogging in power house; 8)leveling of river-bed pools by filling; 9) repairing of the broken margins of canals, removal of stagnant water and deweeding ; 10) channelization of downstream water into main stream to maintain regular flow from the dam area; 11) emptying of breeding sites on weekly basis like : mud pots, containers, ornamental fountains, and buckets; 12) removal of solid waste from peri-domestic areas; 13) demolishing of unused tanks, curing tanks and containers;14) IEC (Information, Education and Communication) activities conducted for local people; 15) radical treatment given to all *Pf* cases; 16) focal spray in the *Pf* incidence villages; 17) frequent inspection of the unconnected parts of the canals along with 18) frequent visits of the health workers in the affected areas. It was difficult to carry out surveys in the back water areas of Jhabua and Badwani districts due to scattered houses and inaccessibility, therefore the local health workers were posted in the villages after suggestion.

Internal review meetings of the project work were done annually by Scientific Advisory Committee (SAC) members of NIMR and external review committee was paneled by experts from Maulana Azad Medical College, Delhi, India which was appointed by NVDA.

Results

MHD and trend during 2004-13 are given in Table-1 and Figure-3. Room density and trend during 2004-13 are given in Table-2 and Figure-4. Figure-5 describes Container Index during 2004-10. Figure-6 describes the total malaria cases during 2004-13. Some of the mitigating measures implemented are described in Figures 1 A-D and 2A-F.

Figure 1A: Indira Sagar Canal before implementing mitigation measure.
Figure 1B: After Cleaning and deweeding of canal.
Figure 1C: Indira Sagar Dam-Downstream flow of seepage water.
Figure 1D: Channelization of water to provide a constant flow.

Figure 2A,2B: Cleaning of ornamental fountain.
Figure 2C,2D: Awareness generation for emptying the domestic breeding sites weekly.
Figure 2E,2F: Demolishing unused hand-pumps and clearing stagnant water in curing tanks.

Before intervention, high density of malaria vector i.e. *An culicifacies* was found as MHD ranged from 2-278 to 4-313 while *An stephensi* was also recorded in the range of 1-8 and 2-9 during 2004-05 (Table-1). Vectors for Filariasis, JE and Dengue i.e. *Culex quinquefasciatus, Culex vishnui* and *Aedes aegypti* respectively were also observed in high densities. After 2005, various mitigation measures were implemented and gradual reduction was observed in MHD during subsequent years. MHD of *An culicifacies* was curtailed to as low as 9 during 2013 for all the study sites while *Culex* and *Aedes* were reduced to zero. The declining trend of MHD was observed from 2006 onwards as given in Figure-3.

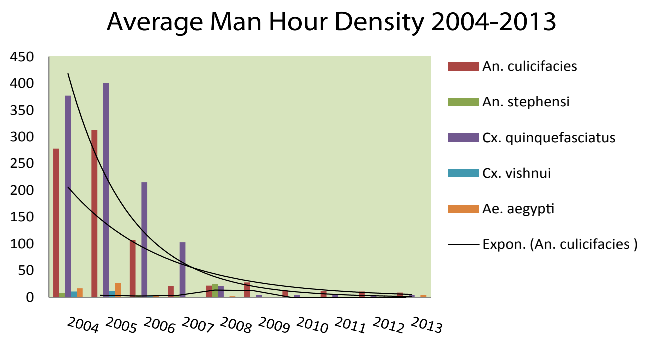

Figure 3: Average MHD of vectors during 2004-2013.
(Expon: Indicates the Exponential trend line, Mov.Avg: Indicates the moving average trendline as per Microsoft Excel 2007).

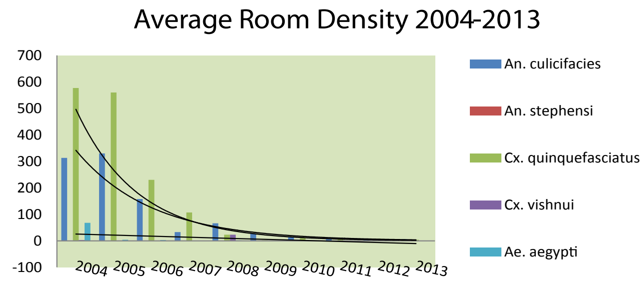

Figure 4: Room density of vector species for 2004-2013.

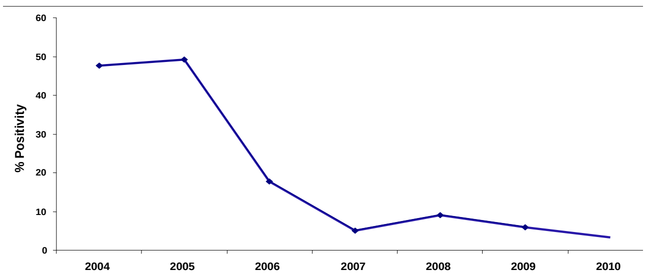

Figure 5: Container Index of *Aedes* mosquitoes during 2004-2010.

Table 2: Room Density of vectors during 2004-2013.

	Malaria		Filaria	JE	Dengue
	An. culicifacies	***An. stephensi***	***Cx. quinquefasciatus***	***Cx. vishnui***	***Ae. aegypti***
Before Intervention					
2004	**4-313**	**3-15**	**21-577**	**0-3**	**0-68**
2005	**5-330**	**0-19**	**5-560**	**0-1**	**0-4**
After Intervention					
2006	**2-158**	**0-7**	**3-230**	**0-1**	**0-3**
2007	**0-33**	**0-1**	**2-107**	**0-1**	**0-1**
2008	**1-66**	**0-3**	**1-23**	**0-23**	**0-1.5**
2009	**0-28**	**0**	**0-2**	**0-1**	**0**
2010	**0-14**	**0**	**0-10**	**0**	**0**
2011	**0-7**	**0**	**0-6**	**0-1**	**0**
2012	**0-6**	**0**	**0-8**	**0-2**	**0**
2013	**0-6**	**0**	**0-4**	**0**	**0**

For the first slot of study, room density was found quite high for malaria vector *An culicifacies* ranging from 4-313 to 5-330. Vectors of Filariasis, *Culex quinquefasciatus* were also observed to be very high ranging from 21-577 to 5-560 for the first slot but for second slot (2006-13), room density gradually decreased to nil (Table-2). The declining trend of room density is given in Figure-4.

For all the water bodies checked preferred larval breeding sites observed during the surveys were seepage of reservoir, pits and pools of down streams, new canals, curing tanks, etc for *Anopheles* and *Culex* while domestic breeding containers were preferred by *Aedes* mosquitoes. Percentage positivity for *Aedes* mosquito in various types of containers i.e. overhead tanks, iron tanks, plastic buckets, plastic drums, mud pots, unused utensils etc, was recorded for the entire period of study. It was also observed to be very high before the intervention period i.e. 2004-05 but due to source reduction and community participation it gradually reduced from 50% to approximately 5% till 2010 (Figure-5).

To assess the prevalent sibling species of *An culicifacies* during 2005-2006 in Khandwa district, 4 villages and 1 RR site were selected randomly and samples were brought to NIMR head quarter for studying polymorphic chromosomes. Observations are compiled in table 3. For village Tikarighat the prevalent sibling species was ‘A’, village Gujjarkhedi comprised of 50% of sibling species ‘A’ and 50% of sibling species ‘C’, village Chandel had 38% ‘A’, 17% B and 45% ‘C’, village Chikdhaliya had 11% ‘A’, 33% ‘B’, and 56% ‘C’ while Sarlaya RR was also found prevalent for 100% of sibling species of ‘A’ of *An culicifacies*. The number of malaria cases rose very high during period of observation but after the mitigation measures implemented the cases reduced to almost negligible. In 2005, out of total 299 slides collected in the survey, 216 slides were found positive for *Pv* and 83 for *Pf*. This was gradually observed to be decreasing for subsequent years and it is worth mentioning that during 2013 only 5 positive cases (3 *Pf* and 2 *Pv*) were recorded from the study site (Figure-6).

Table 3: Prevalence of sibling species in selected villages.

SN	Villages/RR	Percentage of sibling species of vector *An culicifacies*				
		% A	**% B**	**% C**	**% D**	**% E**
1	Tikarighat	100	-	-	-	-
2	Gujjarkhedi	50	-	50	-	-
3	Chandel	38	17	45	-	-
4	Chikdhaliya	11	33	56	-	-
5	Sarlaya RR	100	-	-	-	-

In the cross sectional surveys carried for the JE, Dengue and Filaria from 2004-2009 a total of 6790 blood samples on filter papers were collected and all were found negative. 351 intravenous (I/V routes) blood from fever cases were collected from 2004 to 2008 and the result was found negative for any JE virus. For Filaria, 1041 blood slides were collected during night survey in pre, post and monsoon season during 2004-2008, and these were also found to be negative.

The overall declining trend over different years was observed due to implementation of mitigation measures suggested on various dam components in IVM mode (Figures 1 A-D and 2A-F).

Discussion

The opponents and proponents have long been into discussions

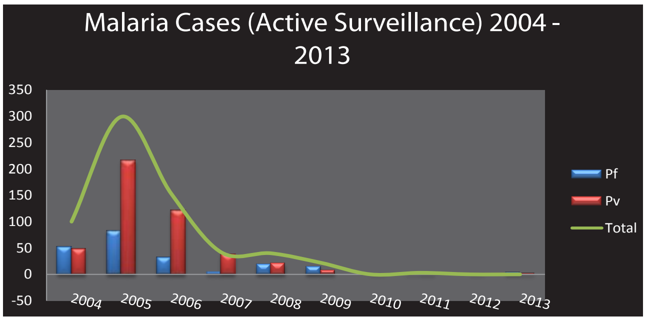

Figure 6: Malaria cases (*Pf* and *Pv*) during 2004-2013.

over the pros and cons of construction of dams. Merely calling them the "temples of development" by the post colonial leaders cannot deny the serious repercussion caused by them to the environment and public health. One of the examples of such adverse impacts was apparent in Sri Lanka where once a malaria free zone became endemic to it [28]. Health Impact Assessment (HIA) is a relatively modern concept defined as "A combination of procedures, methods and tools by which a policy, program or project may be judged in terms of its potential effects on the health of a population and the distribution of those effects within the population" [29]. Health Impact Assessment helps various decision making authorities to take mitigation measures against all the inequalities and maximize the positive impacts on health [30]. There are various examples in which HIA has become an integrated part of the proposed project to avoid the dire consequences on health in future [31]. Initiatives taken like HELI (Health Environmental Linkages) by the World Health Organization have proved to be effective in developing countries to redress the environmental threats. Anophelines being also a brackish water breeder created a humongous problem for Singapore while development of Kranji Reservoir and Sungei Seleter Reservoir [32]. Congregation of labour from endemic areas further increased the risk of malaria transmission in Singapore but practicing environmental control and constant vigilance aimed at demolishing breeding habitat of vector mosquitoes helped to prevent any re-introduction of malaria in these areas.

Present retrospective study emphasizes on taking a proactive approach towards counting on human health while planning major water resources. The cost of these highly ambitious and multi-purpose projects is inferred upon the human health with an already weak and ill-equipped health care sector. Stagnation of water at such a huge scale also alters the natural 10 environment, temperature and humidity which creates and further supports many favourable breeding sites of vector mosquitoes; if not managed well can escalate negative impacts of constructional activities on health [14]. In a report presented by WHO on effect of irrigation and large dams on burden of malaria at global and regional scale, the prevalence of malaria was much higher in irrigated areas as compared to non-irrigated areas under study [33]. To cut down the possible adverse effects of a huge dam construction of small dams was also proposed but in Tigray region even this option faced challenges causing a situation of unstable malaria transmission [34]. The cross sectional surveys showed that children surviving near these small dams were at a 7 fold higher risk as compared to those residing away from these dams. But it also depends upon the prevalence of vector species incriminated for malaria in that area. In a study conducted in Sundargarh district Orissa it was found that construction of small dams can decrease malaria as the vector species *An fluviatilis* is a stream breeder. It could not breed into downstream which was quite prevalent before construction of small dams which consequently decreased the favourable breeding sites as it cut down small streams keeping water stagnant into the reservoir [35]. The sibling species composition concluded that major vector species *An culicifacies* is present in all its form A, B, C, and D in the selected areas. Among these sibling species, only 'B' is the non vector and is reported to be prevalent in East India [36]. It was therefore of much importance to assess the prevalence of sibling species before suggesting any insecticide for indoor residual spray.

Environmental manipulation and modification has taken a front seat while carving control strategies as other means have proved to have serious repercussions on human and environmental health. Present study emphasizes on integrated vector control management to control malaria and vector borne diseases. Modification of human habitat behavior will certainly accentuate the calculated outcome. During observation period i.e. 2004-2005 all possible aspects of disease dynamics were analyzed. Downstream, catchments area and command areas of ISP and OSP were surveyed extensively to find out the possible intervention methods which would eventually open new dimensions to control strategies over conventional methods. After 2005 mitigation measures were suggested to various stakeholders on engineering and entomological aspects. The engineers were suggested to control the seepage of dam and canal by keeping a regular check and lining the canals with plastic sheets. Introduction of *Gambusia affinis* fish was suggested for reservoirs and permanent huge water pools as per standard specification. To increase community participation villagers were sensitized through IEC (Information, Education and Communication) activities. Involving community helped majorly on domestic breeding sites while leveling downstream river-bed curbed the pools and pits which are the most favourable breeding sites for *An culicifacies* which is a major vector for rural malaria. With the current study it can be inferred that an influx of new travelers in the area and labours moving in and out of the villages in search of finding their bread and butter is possibly the reason for some new cases in the area in later stages of studies.

Conclusion

Keeping the fact in mind that environmental manipulation could not be stopped we therefore conclude that Health Impact Assessment should be an integrated part of all the development projects to curtail their negative impacts and maximize the positive ones. Based on findings of current study a pro active approach may be taken for the ongoing constructional activities in Narmada valley for better utilization and allocation of resources. This extensive study is first of its kind in India to assess the impact on health determinants in reference to vector borne diseases of a hydropower project.

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