Civil and Environmental Research
ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)
Vol.3, No.2, 2013

Capacity and Quality Assessment of Awba River Basin

A.G. Okeniyi[1*], S. B. Raheem[2], G. F. Oladiran[3], O. A. Agbede[4]

1. A.G. Okeniyi is affliated with Department of Civil Engineering, The Polytechnic, Ibadan, Nigeria.
2. S. B. Raheem is affliated with Department of Civil Engineering, The Polytechnic, Ibadan, Nigeria.
3. G. F. Oladiran is affliated with Department of Civil Engineering, The Polytechnic, Ibadan, Nigeria.
4. O.A Agbede is a professor, Department of Civil Engineering, University of Ibadan, Ibadan Nigeria

* E-mail of the corresponding author: okeniyiag@yahoo.com

Abstact

This study aims at determining the feasibility of a Mini Water Supply Scheme to meet the growing water needs of The Polytechnic, Ibadan community. The assessment focused on determination of population of the subject community vis-à-vis the location, discharge capacity and quality status of Oba river basin, being the only perennial stream within the community, seeking possible opportunities for capacity building in the areas water based developmental activities. The entire population of the community was obtained by enumeration method with 10years projection considered at a growth of 4 percent on yearly basis. Water budget was arrived at on the basis of per capita per day, in accordance with the United State specification. Raw water supply was obtained through impounding system of reinforced concrete chamber, which serves as an alternative to costly dam construction. Grid survey was carried out to determine the topographical nature along the stream axis at proposed location of the impounding house. Hydrological studies were carried out on the river to obtain its rate of flow and the harvestable volume of raw water at each month of a year. This was used to determine the size of chamber and the impounding hours before pumping. Physico-chemical analysis of the raw water was carried out and the results compared with that of W.H.O's 1996 guide line for drinking water as to dictate the design of treatment plant and the recommendable chemical dosage. The study thus reveals that the available perennial stream within the community is a resource that could be utilized to alleviate the problem of acute water shortage and create better environment for research and other developmental activities of the institution.

Key Words: Population, Raw Water, Capacity and Quality Assessment, Treatment.

1.0 Introduction

Water is an indispensable commodity that is vital for sustainability and improvement of life. According to Tebbutt T. (1990), protoplasm of many living cells contain close to 80 percent water and significant reduction in the content is disastrous, its importance seem to be ineffable while its insufficiency generates inextricable problems and difficulties to every living organism.
Inasmuch as right to water cannot be exchanged for anything, efforts must be intensified to source, assess and develop available water resources within a particular community. This is in addition to the fact that the present world challenges anchored on the needs for capacity development of all facet of life.

The fact still remains that, there is an enormous amount of water on this planet earth, approximately 1.4×10^9 cubic kilometers, in form of oceans, seas, rivers, lakes, ice, and etc. But only 3 percent of the total quantity of water on the earth is in form of fresh water available in rivers, lakes and groundwater. Fresh water is limited, but the requirements for fresh water are

ever on the increase, due to the increase of the population and industrialization.Water is therefore the most important asset for existence, development, maintenance, operations and sanitation.

These areas of utility are principal for community developments, consumption, manufacturing/production, transportation, recreation and sanitation.

In view of the foregoing, a water supply scheme is a necessity for any academic community, as in the case of The Polytechnic, Ibadan.

The Polytechnic, Ibadan is situated in the city of Ibadan, the capital of Oyo State (Fig.01, laminated). It is situated in Ward 8, 27th constituency in North-West Local Government of the Metropolitan Area of Ibadan. It lies between longitude 3°50' and 3°73'E and latitude 7°25' and 7°29'N on coordinates 596 900 and 599 100 Easting and 821 075 and 823 750 Northing. It has population of about 23,000,000 people spread over an area of 229 km^2.

Water is a natural resources but its distribution depend solely on a specific source. The application of this concept is thus limited to having a living stream (perennial) that flows throughout the year within an economic distance contamination level. Hence, available water supplied to fulfill a particular need must also fulfill both quality and quantity requirements. The supply systems can be obtained by any of the numerous types of water resources projects, such as wells, dams or reservoirs.

1.1 Quantity and Quality of Water

Although water is a renewable resource, the many demands for water of a desired quantity and quality in a particular place, requires careful husbandry of supply. After reaching the surface of the earth as rain, water enters a supply system either by penetrating the ground and moving through subsurface channels, known as aquifers, or through runoff into streams and rivers. River-basin management techniques attempt to equalize this variable supply for human purposes, either through watershed management or through the capture of water by dams and its storage in reservoirs. ***Modi P.N. (2004)***

The required quantity and quality of water is of a prime importance in the development of mini-water supply scheme. These determine the type of source storage and treatment required.

The water budget per capital per day by World Health Organization (W.H.O) says: In Africa, it is 100 litres per capital per day. In developed countries, it is 400 litres per capital per day. Any community in Africa that has less than 100 litres per capital per day is water stressed.

According to Ray K.L. and Joseph B.F. (1979), Municipal budget of water are classified as follows:

	Item	**Quantity Range (litre/cap/day)**
i.	Domestic	100 – 300
ii.	Commercial/Institutional/Industrial	40 – 300
iii.	Public	60 – 100
iv.	Loss and Waste	60 – 100

Water quality is a standard that measures or defines acceptability of a particular source for a specific purpose. This quality is accessed in terms of physical, chemical and biological characteristic and it is intended uses. Hence, water sampling for analysis must be the

representative of the source and equipment, procedure and techniques must be carefully selected to avoid changes in constituents to be analyzed before it is carried out.

1.2 Sources of Water

Surface water and groundwater are both important sources for community water supply needs. Groundwater is common source for single homes and small towns, rivers and lakes are the usual sources for large cities. Approximately 98 percent of liquid fresh water exists as groundwater, much of it occurs very deep in the Earth. This makes pumping very expensive, preventing the full development and use of groundwater resources, Agbede O.A. (1998).

1.2.1 Forms of Water at Sources

Water is available in forms ranging from **Solid (**as in ice) to **liquid (**e.g water) to **Gaseous** in form of vapour. Variation in the amount of energy absorbed from the sun changes in the state of water resulting in the hydrological cycle.

Water Quality And Health: For over 50yrs the World Health Organization (W.H.O) has been concerned with drinking water quality and its effect upon human health. A major W.H.O function to achieve such goal is the responsibility. “To propose regulations and to make recommendations with respect of international health matters”. Guidelines values ensuring bacteriological physical and chemical safety drinking water supplies as recommended by W.H.O, 1984 and 1996, are shown Table 01below.

2.0 Methodology

To achieve the objectives of the study, Data of geological nature, topographical map, rainfall intensity curve, run-off co-efficient and population data were obtained and used as detailed below.

2.1 Survey

Study location survey was carried out along the stream to obtain reasonable and reliable data

2.2 Hydrological and Hydraulic Analysis

Hydrological information was obtained based on land used pattern in the master plan of the institution, while the hydraulic data was obtained for twelve calendar month of a year. This was to determine hydrological yield and the capacity of impounding reservoir for collection.

- Catchment Area Measurement was done by the use of grid lines and planimeter on topographical map

- Determination of Run off Coefficient, C was based on conditions as applicable to infrastructural developmental plan of the institution viz-a-viz the topographical terrain of the area.

- Stream Flow Studies was carried out at a pipe culvert location along its channel to obtain the velocity of flow, discharge and the hydrograph.

2.3 Raw Water Parameter Analysis

Samples of Oba stream water were obtained and analysed to determine level of contamination and also help decision in the design of treatment dosage.
Community Population:- The total number of people in the institution including resident and off campus students, staff, traders and business centre operators were enumerated in the following categories;

- The Residential/Domestic
- The Research/Commercial (Academics)
- The Public Use

i. **The Residential/Domestic group:** This is the category that belongs to the occupants residing permanently within the community – The Polytechnic, Ibadan. These are resident lecturers/staffs and resident students. Enumeration exercise involves hostels and staff quarters.
ii. **The Research/Commercial group**: This is the category that belongs to academic set-ups. It is the number of people who works and study/practice in the workshops and laboratories.
iii. Public Use group: This category is sub-divided into two – services and other services.
(a.) Services: This is the category that comprises of classrooms, offices, departments, fire station, lecture theatres, halls, health center, etc.
(b.) Other Services: This category comprises of the users of kiosks, business centers, and canteens.
Having obtained the total number of the occupants in The Polytechnic, Ibadan community, the population was projected for a specific year of design, using the under stated expression:

$$P_n = P_o (1+r)^n$$

Where, P_n = Projected Population
P_o = Estimated Population
r = Growth Rate
n = Number of years of projection generally between 10 and 30 years.

According to the World Health Organization (W.H.O.), for Nigeria, growth rate is 4%.

2.4 Raw Water Sampling

The tributary of the subject river (Oba stream) originates in the south-eastern fringe of the University of Ibadan and the catchment area has it boundary within the academic environment and that of The Polytechnic, Ibadan.

The water sample was taken at the proposed impounding location on a noted day and time and was taken to the laboratory. The physico-chemical tests of the raw water were carried out to determine key properties for analysis.

3.0 Results and Discussion

3.1 Results

Grid Survey: Survey of the stream axis within the proposed point of collection at coverage of about 10,000m^2 describes the terrain of the area and the flow of the stream using leveling instruments. The survey was carried out by dividing the coverage area into grid form of 10m x 10m, taking level at each grid point and obtained the reduced values using "height of instrument method". Detail in fig 02

3.2 Population Projection: Population projection was considered per group in order to achieve accuracy, expressed as;

$$P_n = P_o (1+r)^n$$

Where,

P_n = Projected Population

P_o = Estimated Population

r = Growth Rate, 4% (W.H.O. standard for Nigeria)

n = Number of years of projection, 10 years.

The total population projection = **33,486 occupants**

Required Volume of Water: The required volume of water demand by the occupants has to be obtained per class/group based on the specification as shown in table 2.0.

Therefore, the total volume of water demand is Three Million, and Fifty One Thousand (3,051,000) Litres, which is **3204m^3 per day**.

Sources of Raw Water: Oba stream was the proposed source of raw water supply, due to its perennial nature. It flows throughout the year, hence considered suitable for the supply purpose of raw water.

Oba stream originates from Oba dam in the University of Ibadan and flows through The Polytechnic into the Apete lagoon, and finally to Eleyele River. Thus Oba stream is one of the tributaries discharging to Eleyele River.

Hydrological Analysis of the Stream: (a) The Coefficient of Runoff, C from Table 03, runoff coefficient for design was obtained based on the hilly condition of the catchment area as follows;

i. Pavement and Roof = 60%
ii. Cultivated Land, Sand and Gravel = 15%
iii. Play Ground = 5%
iv. Woodland and Forest = 15%
v. Unimproved Area = 5%

The weighted average is

60% of 0.90 + 15% of 0.35 + 5% of 0.30 + 15% of 0.20 + 5% of 0.30

C = 0.7

(b) Rainfall Intensity (I) for 50 years return period obtained from standard curve,

I = 174mm/hr *(Source: Osot and Associates (1997))*

= 0.000483m/s

(c) The Catchment Area, A was determined using Planimeter and result thereafter compared with manual grid method on a topographic map of 1:10,000. Estimated catchment area is 1,450,000 m^2.

(d) Discharge, Q obtained as; $Q = C.I.A = 0.7 \times 0.000483 \times 1{,}450{,}000\ m^3/s$
$= 49.030\ m^3/s$

The flow rate on monthly basis estimated from; Q = V.A

Where,

V = velocity of flow in m/s and

A = area of wetted perimeter of culvert in m^2 is as follows

LABORATORY ANALYSIS OF RAW WATER:- The parameters investigated are colour, turbidity, pH, temperature,dissolved oxygen e.t.c, see table 5.1 below. The results were compared with the World Health Organization (W.H.O) Standard of 1996 as to serve as guide in the design of treatment plant and recommendation of the treatment chemical dosage.

COMMENT AND RECOMMENDED DOSAGE: The physical and aesthetic property of water are objectionable satisfactory. The pH, total alkanity and the hardness are relatively satisfactory.

The process of aeration shall be required to facilitate the elimination undesirable metals (e.g. Iron) through oxidation process while an active coagulation process is necessary to normalize the total solids present in the water. A good coagulant aid such as Hydrated Lime is required to counter acidic and coagulative effects.

The water requires a proper disinfection with chlorinous compound to make it safe for human consumption.

Recommended Dosages:

Aluminium Sulphate (Coagulant)	= 70mg/liter
Desinfectant Demand	= 2.5198mg/liter
Coagulant Aid	= 18mg/litres

Alternatively, Ferric Chloride $(FeCl)_3$ is also used as coagulant where more heavy flocs formation is desired to create larger velocity for the process.

It is again used if the addition of sulphate ions that was released to the water by use of Alminium Sulphate is unwanted as sulphates in high concentration may create a slightly bitter taste to portable water.

Meanwhile, $(FeCl)_3$ has a significant larger corrosion potential compared with Aluminuim Sulphate and attacks especially carbon steel and stainless steel very quickly and badly.

CONCLUSION

Water is a necessity for all living things. Human developments in terms of personel and environmental depends mainly on availability of water. Hence presence of a living stream within a particular community is a resource that must be utilized. The required quantity of water for The Polytechnic community was estimated and projection made based on the estimated water demand per capita per day, for all sort of water uses. The demand was compared with the quantity obtainable from the source perennial Oba stream at a point, few distance away from the outlet of a cross culvert around Maintenance area of the institution. The hydrological study conducted on the stream confirms that the subject stream is capable of supplying the needed raw water. This stands a better alternative to an expensive water tanker supply, which has being the system throughout the seasons.

In view of the foregoing, a mini water supply scheme is confirmed feasible for The Polytechnic Ibadan community as a case study for communities of like- population and resources.

References

Agbede O.A. (1996), Ground Water Modelling – An Overview. A Publication of Geological and Mining Society of Nigeria Journal. Vol. 32, 1996, No. 2, pages 105 – 112.

Agbede O.A. and Morakinyo J.A. (2001), Rainwater Harvesting Prospects In Rural Communities In Nigeria. A Publication of Nigeria Journal of Science, Volume 35 No 3, Pages 265-270.

Agbede O.A. (1988), Optimization Studies of Groundwater in Northern Nigeria. Modelling, Simulation and Control Journal, Volume 14 No 4, Acme Press, Page 7

Jenkins D. (1982) Water Science And Technology, University of California, Berkeley, U.S.A. Pergamon Press.

Department of Environmental and Central Office of Information, Water Treatment Technology, U.S.A.© 1979

Punmia B.C. , Pande B.B. Lal (1992), Irrigation And Water Power Engineering, Twelfth Edition, Laxmi Press.

Jonas M.K. Dake (1974), Essential of Engineering Hydraulics, Reprinted Edition of the First

Subramanya K. (2000), Engineering Hydrology, Second Edition.

Al-Layla M. et al, Water Supply Engineering Design, Ann Arbor Science Publishers Incorporated.© 1977

Linsley R. K., Franzini B. J. (1972), Water Resources Engineering, Third Edition.

The Cooperative Research Center for Water Quality and Treatment (2000), Drinking Water Treatment. C.R.C. (Australia).

Howard, S. P., et al (1985) , Environmental Engineering, Mc Graw- Hill book Co. New York. N.Y

Tchobanglous, G. and Schroeder, E.D (1985), Water Quality, Addison – Wesley Publishing Company, Massachusetts.

Imam, Mc Corquodale, J.A. and Bewtra J.K. (1983), Numerical Modelling of Sedimentation Tanks, Journal of Hydraulic Engineering, Vol 109, N0. 12.

John , W.C and Warren, V. Jr. (1965), Water Supply and Pollution Control. International Text book Company, Scranton, Pennsylvania.

Tebbutt, T. (1990), Basic Water and Wastewater Treatment. Butterworth & Co. (Publishers) Ltd, London.

Modi P.N. (2004), Irrigation Water Resources and Water Power Engineering. Rajinder (Publisher) Naisarak, Delhi.

WHO (1971, 1984 & 1996), Guideline for Drinking Water Quality.

British Standard Institution (1999), BS 811O for Reinforced Concrete. Part 1

Federal Ministry of Works (1973), Highway Design Manual, Part 1

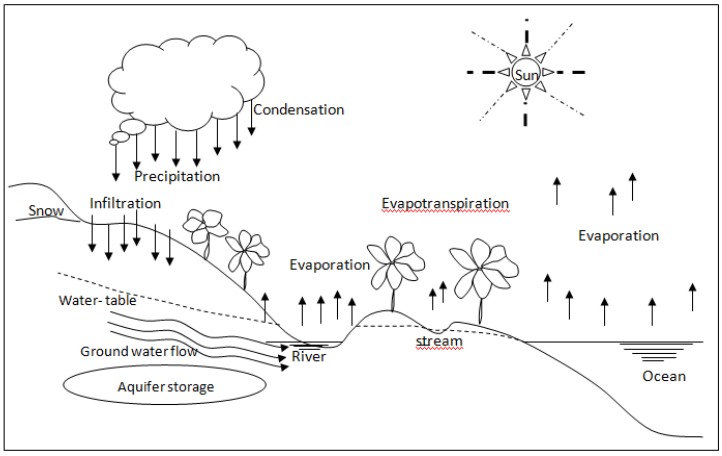

Fig. 01: The hydrological Cycle

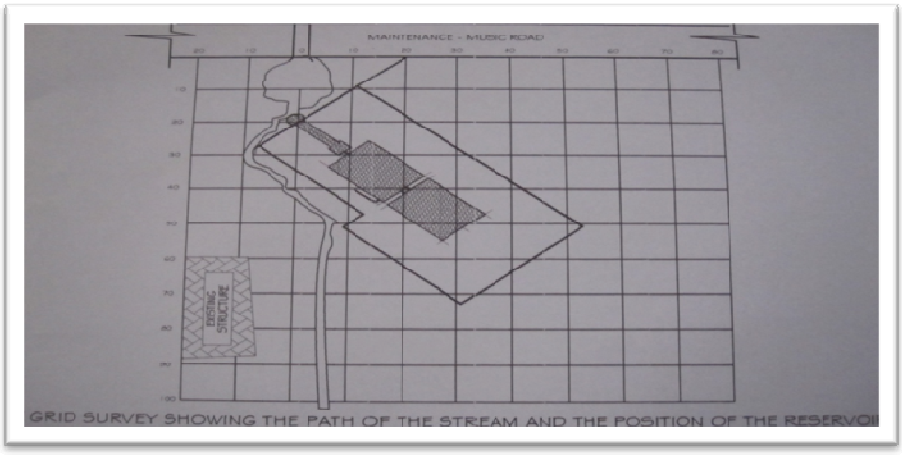

Figure 02: Grid Showing the Stream Course

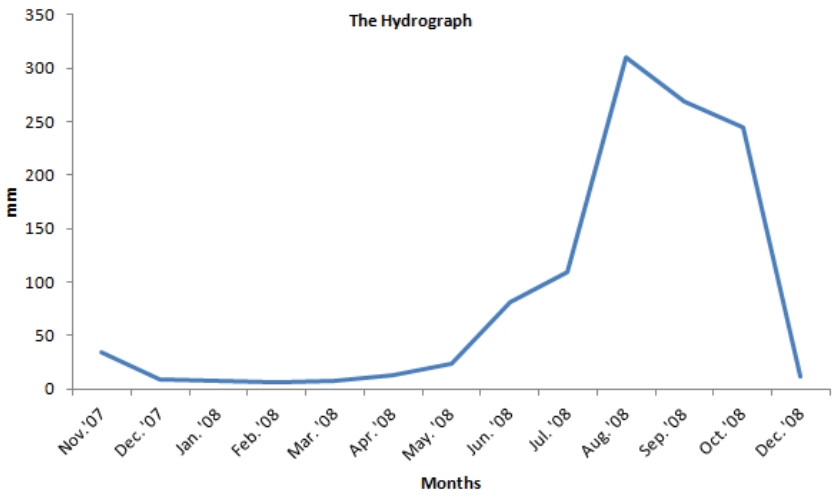

Fig 03: The Hydrograph

Hydrograph showing the monthly distribution of water flow at a cross culvert point of the subject stream, Fig. 02.

Table 01: W.H.O Guidelines for Drinking Water

S/No	Constituent or Characteristic	Guideline Value
1	Arsenic	0.05mg/l
2	Cadmium	0.05mg/l
3	Chromium	0.05mg/l
4	Cyanide	0.1mg/l
5	Fluoride	15mg/l
6	Lead	0.05mg/l
7	Mercury	0.001mg/l
8	Nickel	0.1mg/l
9	Nitrite and Nitrite Nitrogen	10mg/l
10	Nitrite Nitrogen	1.0mg/l
11	Selenium	0.01mg/l
12	Chloride	250mg/l
13	Sulphate	400mg/l
14	Hardness as CaCo3	500mg/l
15	Total dissolved Solids	1000mg/l
16	Aluminum	0.2 mg/l
17	Copper	1.0mg/l
18	Iron	0.3 mg/l
19	Manganese	0.1 mg/l
20	Sodium	200 mg/l
21	Zinc	5.0 mg/l
22	Chlorophenols	0.1 mg/l
23	Chloroform	30
24	DDT	1
25	Heptachlor	30
26	Lindane	3
27	Monochlorobenzene	3
28	1,4 - dichlorobenzene	0.1
29	2, 4 -0	100
30	Gross alpha activity	0.1Bq/l
31	Gross beta activity	1
32	Colour	15TCU
33	Turbidity	5NTU
34	Taste /odour	Inoffensive to Consumer
35	pH	6.5 - 8.5

(Source: W.H.O. 1996)

Table 02: Projected Population and The Required Volume Of Water

S/No	Group Description Litres /Capita /Day	Litres /Capita /Day	Projected Popu.	Req.Vol./ Day
1	Residential Occupants	150	11472	1,720,800
2	Academics Services	100	234	23,400
3	Public Services	60	21780	1,306,800

Table 03: The Flow Rate of Oba Stream

MONTH	AREA OF WETTED PERIMETER (m^2) 3 No. of Culvert	VELOCITY OF FLOW (m/s)	FLOW RATE	
			m^3/hr	m^3/day
November	0.0195	0.480	33.70	746.50
December	0.075	0.305	8.24	155.52
January	0.075	0.265	7.16	134.78
February	0.006	0.256	5.53	64.80
March	0.0075	0.295	7.97	150.34
April	0.0105	0.354	13.38	272.16
May	0.015	0.427	23.06	544.32
June	0.033	0.685	81.38	1938.82
July	0.039	0.780	109.51	2628.29
August	0.075	1.150	310.50	7452
September	0.069	1.080	268.27	6438.53
October	0.066	1.030	244.73	5873.47

Table 04 : Physico- Chemical Test On The Stream

PARAMETERS	TEST RESULTS	W.H.O (1996) STANDARD	REMARKS
Point of Collection	Stream		
Date and Time of:			
- Collection	11/02/09(11.45 A.M)		
- Arrival in the laboratory	11/02/09		
- Analysis	12/02/09		
Appearance	Fairly Clear		Less satisfactory
Colour	Objectionable	5	Ditto
Colour(HU)	20	6.5 – 8.5	Normal
pH	7.3	200	Satisfactory
Total Alkalinity (mg/l)	62.4	500	Ditto
Total Hardness (mg/l)	58.8	500	Ditto
Calcium Hardness (mg/l)	38.6	200	Ditto
Calcium (mg/l)	15.47	250	Ditto
Chloride (mg/l)	28.4	0.3	Satisfactory
Iron (mg/l)	0.18	1000	Ditto
TDS (mg/l)	692.8	-	Normal
DO (mg/l)	13.4	0 in 100ml	No guideline
Total coli form	120		Slightly high
Chlorine Demand(mg/litre)	2.5198	-	High and signif.
Temperature (^{o}C)	26.4		No guideline

This academic article was published by The International Institute for Science, Technology and Education (IISTE). The IISTE is a pioneer in the Open Access Publishing service based in the U.S. and Europe. The aim of the institute is Accelerating Global Knowledge Sharing.

More information about the publisher can be found in the IISTE's homepage: http://www.iiste.org

CALL FOR PAPERS

The IISTE is currently hosting more than 30 peer-reviewed academic journals and collaborating with academic institutions around the world. There's no deadline for submission. **Prospective authors of IISTE journals can find the submission instruction on the following page:** http://www.iiste.org/Journals/

The IISTE editorial team promises to the review and publish all the qualified submissions in a **fast** manner. All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Printed version of the journals is also available upon request of readers and authors.

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar