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Water Quality Assessment of Hand Dug-Wells and Treatment with *(Moringa Oleifera)* Powder in Mubi, Adamawa State, Nigeria

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Abstract

The status of eighteen (18) hand dug well-water samples from six selected wards (Yelwa, Lokuwa, Sabon-layi, Kolere, Digil, and Wuro-patuji) in Mubi town was determined by evaluating the physical, chemical and microbiological properties of hand dug well-water samples. The objectives of the study is to investigate the physical, chemical and biological characteristics of hand dug wells in Mubi metropolis of Adamawa state and to proffer solutions to the problems of the hand dug wells. The work involved sample collection and analysis to determine the physical, chemical and microbiological properties of hand dug-well water in Mubi. Three (3) water samples were collected from each of the 6 locations once a month for a period of 12 calendar months (1year), and analyzed. The parameters investigated include Turbidity, Colour, Odour, Temperature, Taste, Total suspended solids (TSS), Total Dissolved Solid (TDS), Electrical Conductivity (EC), pH, Sodium, Magnesium, Calcium, Fuoride, Nitrate, Potassium, Sulphate, Total Coliform and Escheria Coliform respectively, using standard methods. A Filtering device developed, made from a jute sack and ply wood was used to filter suspended materials in the water. The results were compared with the available standard requirement for water use. The physical properties (Odour, colour, taste, TSS, TDS, Turbidity and temperature) were found to be within the acceptable limit for safe drinking water quality specified by standards. The chemical properties (pH, F, Cl, Na, Ca, Mg, SO_4, NO_3, K and conductivity) were also found to be within the acceptable limits for safe drinking water quality earlier specified by standards). The microbiological properties (T. coli and E. coli) equally revealed that their values were far above the permitted levels for safe drinking water quality. Moringa powder (water purifier) proportionally reduced the concentration of microbiological contaminants with increasing application rates in the hand dug-well water studied. The T. coli population dropped from 166 cfu/l (for 0 g of moringa powder ie. no treatment) to 83 cfu/l (for10 g of moringa powder), then 45 cfu/l (for 20 g moringa powder), and 0 cfu/l (for 30 g of moringa powder). Similarly, the E. coli also reduced from 78 cfu/l (for 0 g moringa powder) to 47 cfu/l (for 10 g moringa powder) and to 0 cfu/l at both 20 and 30 g of moringa powder application rates. From the results of this study, it is recommended that treatment of hand dug-well water with 20g/l of moringa powder is highly recommended before consumption. It is also recommended that hand dug-well water users should be sensitized on the need for prompt sanitation of their hand dug-well surroundings in order to curtail microbiological contamination. The State Government should reactivate the existing water treatment plant in the town so that treated water should be made available to the population for their consumption. Awareness should be created among the population on where to site and construct hand dug-well in order to reduce the risk of being contaminated. This will help to minimize water borne diseases. Hand dug-well water users should be educated on how to treat their water with moringa powder before consumption.

Keywords: *Contamination, Moringa, Micro-biological, Water sources, Purification*

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Background to the Study

In ancient times, water was mostly stored in tanks, pots and buckets while, some people harvested rain water from the roof tops of houses and kept for use during rain fall absence especially during the dry season (Tebutt, 1980). The increased demand for water resulted in tapping of ground water from springs and hand dug wells. Shallow and permeable water table aquifersare most susceptible to contamination (Moody. 1986).Drinking water must be within tolerable use-limits for human consumption. Water taste, colour, odour, SAR, pH and salinity (EC) status standards (Schwab, et al 1992).

Generally, hand dug-wells are 10-15 meters deep. In many societies, according to Schotanus (2008), there are local experts with the knowledge and expertise developed through years. According to him designs vary according local preference and condition of and are suitable for areas with firm soils. The wells are said to be sand point if they are not cased. In Mubi metropolis local well diggers dig the wells at an affordable price. Until recent centuries, all artificial well were pump lesshand-dug wells of varying degrees of formality, and they remain a very important source of potable water in some rural, developing areas where they are routinely dug and used today (Schotanus2008).

In many countries, availability of water has become a critical and urgent problem for countries without access pipe borne water (Okonko and Adajoye. 2008). There is need to control the pollution of surface and ground water since the public health of the people have a direct link with the availability of adequate quantity and good quality water (Alao et al, 2010). A significant number of the population in the study area depends on well water for their drinking and other domestic purposes, and there has been a lot of complaints about the quality of the well water in terms of biological, chemical and physical contamination. Available records obtained from Mubi General Hospital and the Local Government Primary Health Care Office revealed that the rate Water borne diseases is so alarming in the study area One method of determining bacteria counts is to count the number of bacteria colonies that grow on a prepared medium. According to World Health Organization water for human consumption must be free from microbial indicators of fecal contamination and coliform count per 100 ml of drinking water must zero (WHO, 2011).

Drinking water should not contain more than 10 total coliform bacteria per 100 ml of water(Canada's guideline for drinking water quality 1996,), any water containing more than this amount should be resampled. If the repeat sample contains more than 10 total coliform bacteria per 100 ml corrective action should be taken immediately water containing fewer than 10 total coliform bacteria per 100 ml is considered marginally safe to drink. Nevertheless the water should be re-sampled. According to Wyeret 1996 the fecal pollution level was higher in the wet season compared to the dry season. Studies of microbial concentration shows these pollutant to be total coliform, fecal coliform and fecal streptococci. The presence of fecal coliform (E. coli) serves as an indication of contamination by sewage. Microbial pathogenic parameters are typically of greatest concern because of their immediate health risk. Pinford (1990) identified Salmonella as the most significantly common fecal contamination of water source by septic effluence. Coliform bacteria may not cause disease, but be indicators of pathogenic organisms that

cause diseases. The latter could cause intestinal infections, dysentery, hepatitis, typhoid fever, cholera and other illness. However, these illnesses are not limited to disease causing organism in drinking water. (Texas Soil Water Conservation Board 2000).

Moringa Oleifera kernels are biological coagulant consisting of significant quantities of low molecular weight water soluble proteins, which in solution carry out an overall positive charge. The proteins are considered to act similarly to synthetic, positively charge polymer coagulant. When added to raw water the protein binds to the predominantly negatively charged particles that make the raw water to Turbid (Silt, clay, bacteria). Under proper agitation these bond particles then grow in size to form flocs (Abdulsalam and Gital 2007). Crushed moringa seeds clarify and purify water to suit domestic use and lower the bacterial concentration in the water, making it safe for drinking. Moringa seeds powder can be used as a quick and simple method forcleaning dirty water. Studies showed that this method of filtering not only diminishes water pollution but also harmful bacteria. Moringa powder joins the solid in the water and sinks to the bottom. This treatment also removes 90-99% bacteria contained in water. A literature review indicates that moringa coagulate 80.0% to 99.5% turbidity (surrogate for suspended particles) and colour (Surrogate for natural organic material), efficiently leading to a aesthetically clear supernatant. As a safer indicator, this was currently accompanied by a 90.00% to 99.99% bacteria load reduction (fecal coliform), with bacteria concentrated in the sediment sludge (Madsen et al, 1987). Moringa flocculants released from crushed seeds kernels has been characterized as basic polypeptides with a molecular weight of between 6 and 7 kg (Jahn, 1988) and isoelectric pH of 10 to 11 (Folkard and Sutherland, 2001). They bind suspended particles in a colloidal suspension, forming large sedimenting particles (Flocs) that include pathogenic microorganisms (Madsen et al, 1987).The objectives of the study is to investigate the physical, chemical and biological characteristics of hand dug wells in Mubi metropolis of Adamawa state and to proffer solutions to the problems of the hand dug wells. The study was limited to the status of eighteen(18) hand dug well water samples from six selected locations in Mubi metropolis and these are Lokuwa, Kolere,Yelwa, Sabon-layi,Wuropatuji and Digil respectively. The study has lasted for a period of 12 months.

Objective of the Study

The objectives of the study is to investigate the physical, chemical and biological characteristics of hand dug wells in Mubi metropolis of Adamawa state and to proffer solutions to the problems of the hand dug wells.

Methodology

Study Area

The study was carried out at Mubi North local government area, and is located in the Northern part of Adamawa State Nigeria. It lies between latitudes 10° 14^{1} and 10° 19^{1} N, and between longitudes 13° 13^{1} and 13° 18^{1} E. It borders Borneo State to the West, Maiha and Hong LGA to the South and Michika LGA to the North, while its eastern boundary is belted by the Mandara Mountains to the Cameroon Republic (Fig.1). The area has about 506.4 square kilometers (km) with a population size of 759,045 at a density of 160.5 people per square kilometer (Nwogboso and Uyanga, 1999). The area has a tropical wet and dry climate, with

dry season lasting for a minimum period of5 months (November to march), while the wet season spans between April and October, each year. Annual rainfall amounts ranges from a mean minimum of 700mm to a mean maximum of 1,050mm (Adebayo,2004). The main occupation of the people in the area is mainly arable farming and livestock production.

Plate 1. **Moringa seed and Filtering Device**
The seeds of *Moringa Oleifera* were obtained and then sundried. The seeds were crushed to powder using a motor and pestle. A digital weighing balance was used to weigh the powder into 10 g, 20 g and 30 g.

Collection of hand dug-well water Samples
One (1) litre of water samples was randomly collected from 18 selected hand dug-wells in 6 locations, 3 sample each from Kolere, Lokuwa, Sabon-layi, Yelwa, Wuro-patuji and Digil respectively. The samples were collected using a bucket and a rope system. Each sample was poured into a 1 litre sterile bottle and labeled for prescribed laboratory studies.

Results

Table 1: Mean Values of Physical properties Compared with Standard

Month	TSS(mg/l)		TDS(mg/l)		Turbidity(NTU)		Temp(°C)	
	Mean	Limit	Mean	Limit	Mean	Limit	Mean	Limit
May	22.06	200	31.78	500	3.26	5	28.9	
June	29.89	200	7.53	500	2.24	5	27.6	
July	33.61	200	19.28	500	1.99	5	26.8	
August	35.83	200	16.66	500	2.57	5	25.7	
September	35.26	200	14.66	500	2.57	5	25.5	
October	33.58	200	18.13	500	2.37	5	26.3	
November	16.39	200	20.96	500	1.63	5	26.7	
December	27.61	200	26.41	500	1.34	5	27.5	
January	100.56	200	42.83	500	1.09	5	25.7	
February	147.00	200	60.04	500	0.52	5	26.5	
March	80.33	200	55.41	500	0.73	5	27.8	
April	156.83	200	49.50	500	0.83	5	32.5	

Source: (Laboratory analysis 2013-2014)

The physical properties of 18 hand dug well water samples in the study were analysed in the laboratory for the study period. Samples from 15 wells appeared colourless, and unobjectionable in terms of odour and taste which are within the stipulated limit by Nigerian Industrial Standard (NIS), Standard Organization of Nigeria (SON) and National Agency for Food and Drug Administration Control (NAFDAC) (2007).This agrees with the range reported by Tekwa (2007), while examining hand dug-well water quality and use in Mubi. Slightly coloured samples were observed in 3 wells which had no cover, and the opening edge casing was not raised high enough above the ground level. This slightly colouring was observed during the rainfall peak (June – September). During this period decayed materials are easily transported by surface run off and by seepage through surface soil.

Color can be caused by decaying leafs, plants, organic matter, copper, iron, and manganese, which may be objectionable. Total Suspended Solids (TSS) refers to the filterable solids in a liquid medium that can be filtered using a filter, it is also the amount of soil moving in water.The TSS value ranged from 16.39mg/l to 156.83mg/l (Table 4), which is below the maximum limit of 1000mg/l recommended for drinking water stipulated by NIS, SON and NAFDAC, (2007). The value of TSS was recorded high 156.83mg/l in the month of April, this could be attributed to the fact that this period was the beginning of the rainfall of which, sand storm and dust usually occurs before rainfall. However with this value recorded the hand dug-well water is safe to drink in this respect.

The Total dissolve Solids found in this study ranged from 14.66 – 60.04mg/l (Table 1), which is below the maximum limit recommended for standard drinking water stipulated by NIS, SON and NAFDAC, (2007). The water is safe to drink in terms of TDS. TDS above maximum

limitmay affect taste adversely and cause deterioration in plumbing pipes. The EPA recommends that water containing more than 500 mg/l of dissolved solids must not be used. Health wise, water containing more than 500 mg/l of TDS is not recommended to drink.

Turbidity is the amount of particulate matter that is suspended in water caused by the presence of suspended matter such as clay, silt, and fine particles of organic and inorganic matter. The Turbidity value recorded in this study ranged from 0.52 – 3.25NTU, (Table 1). This range of values fall below the maximum limit of 5 NTU stipulated by NIS, SON and NAFDAC, (2007). Turbidity was recorded high in the month May (3.26 NTU), this was attributed to the fact that this period was the beginning of rainfall of which rainstorm, particles from the surrounding land are washed into the well making the water slightly muddy color.Temperature values obtained from this study ranged from 25°C – 28.9°C (Table 1). This range is acceptable under NIS, SON and NAFDAC, (2007) standard which should be 'ambient', that is temperature of the immediate surrounding environment and should be acceptable to most consumers.

Table 2: Chemical Properties Compared with Standards

Month	pH		Flouride(mg/l)		Chloride (mg/l)		Sulphate(mg/l)		Nitrate (mg/l) .	
	Mean	Limit	Mean	Limit	Mean	Limit	Mean	Limit	Mean	Limit
May	6.56	8.5	1.23	1.5	98	250	54	100	40.30	50
June	7.11	8.5	1.30	1.5	101	250	54	100	45.28	50
July	6.93	8.5	1.36	1.5	102	250	54	100	46.48	50
August	6.97	8.5	1.34	1.5	109	250	55	100	44.88	50
September	6.97	8.5	1.29	1.5	79	250	51	100	43.74	50
October	7.09	8.5	1.24	1.5	76	250	49	100	41.74	50
November	7.15	8.5	1.13	1.5	90	250	47	100	39.72	50
December	7.17	8.5	1.05	1.5	86	250	44	100	36.16	50
January	7.18	8.5	0.97	1.5	83	250	44	100	34.71	50
February	7.17	8.5	0.88	1.5	83	250	45	100	33.91	50
March	7.18	8.5	1.17	1.5	93	250	49	100	33.56	50
April	7.08	8.5	1.33	1.5	111	250	57	100	45.29	50

Source: (Laboratory Analysis 2013-2014)

pH is a measure of the free hydrogen ion and hydroxyl ions in the water. A pH of 7 is neutral. pH under 7 indicates acidity; higher than 7 indicates alkalinity. Drinking water with a pH between 6.5 and 8.5generally is considered satisfactory.

The pH values of the study ranged from 6.56 – 7.0 (Table 5). This range is below the maximum permissible limit of 8.5 stipulated by NIS, SON and NAFDAC, (2007). With this value recorded the water safe to drink. The pH values for the month of May, June and August showed an acidic concentration, while the rest of the months are alkaline in nature. Fluoride concentrations of 0.7 to1.2 mg/l in drinking water will protect against dental cavities. However, excessive levels (more than 1.5 mg/l) may cause discoloration, or mottling of the teeth.Fluoride concentration ranged from 0.88mg/l to 1.17mg/l (Table 2). This range is below

the maximum limit of 1.5mg/l for drinking water quality stipulated by NIS/SON/NAFDAC, (2007),(Table 16). The water is safe to drink in terms of fluoride.

High concentrations of chloride ions can cause water to have an objectionable salty taste and corrode hot-water plumbing systems. The value of chloride recorded ranged from 83mg/l to 111mg/l, (Table 6). This range is far below the maximum permissible of 250mg/l for safe drinking water quality stipulated by NIS/SON/NAFDAC (2007). The water in the study area is safe to drink in terms of chloride. It was observed that concentration of chemical properties was recorded higher in raining season compared to dry season because of increase in volume of water in the well. This was attributed to the fact in raining season the water table seems to be high. Sulphate value ranged from 44mg/l to 57mg/l (Table 2), this range is also below the maximum limit of 100mg/l for drinking water quality stipulated by NIS/SON/NAFDAC, (2007) as indicated in(Tables 9)this revealed that the water is safe to drink. The concentration of Nitrate ranged from 33.56mg/l to 46.48mg/l, (Table 2). This range is below the maximum limit of 50mg/l for drinking water quality stipulated by WHO (2010), (Table 9), as such the water is safe to drink in this respect.

Table 3: Chemical Properties Compared with Standards

Month	**Sodium(mg/l)**		**Magnesium (mg/l)**		**Calcium (mg/l)**		**Potassium (mg/l)**		**Conductivity (µS/cm)**	
	Mean	Limit	Mean	Limit	Mean	Limit	Mean	Limit	Mean	Limit
May	5.41	200	6.29	0.20	24.39	200	50	70	54.9	1000
June	5.49	200	6.14	0.20	24.78	200	52	70	49.8	1000
July	5.63	200	6.55	0.20	25.30	200	54	70	43.2	1000
August	5.92	200	5.45	0.20	24.58	200	56	70	40.1	1000
September	4.57	200	5.076	0.20	24.51	200	58.5	70	38.8	1000
October	3.89	200	4.83	0.20	23.91	200	51.8	70	38.03	1000
November	3.25	200	4.58	0.20	22.48	200	48	70	46.8	1000
December	3.25	200	4.29	0.20	21.40	200	48	70	62.8	1000
January	3.31	200	3.80	0.20	20.65	200	48	70	87.3	1000
February	3.33	200	3.71	0.20	20.17	200	47	70	105.8	1000
March	3.35	200	3.45	0.20	20.36	200	48	70	128.0	1000
April	3.40	200	6.52	0.20	25.58	200	50	70	90.8	1000

Source: (Laboratory analysis 2013-2014)

The concentration of Sodium range from 3.25mg/l to 5.92mg/l. (Table 3) this range is also for below the maximum limit of 200mg/l for drinking water quality stipulated by NIS/SON/NAFDAC (2007).The water is safe for drinking in terms of Sodium. It was observed that the concentration was recorded higher in raining season compared to dry season due to the fact that the rising water table during these period and also couple with the fact that water run-off flowing into some of the wells that do not have their casing risen high above ground level, Also infiltration of contaminated water into wells that do have cracks on their wall casing. The value of magnesium ranged from 3.45mg/l to 6.52mg/l, (Table 6). This value is lower than the maximum permissible limit of 125mg/l for drinking water quality

reported by North Dakota State University Water Quality Interpretive Tool, 2012.This revealed that the water is safe for drinking in terms of magnesium. The concentration of calcium ranged from 20.17mg/l to 25.58mg/l, (Table 3).

The value Potassium range from 48mg/l to 56mg/l, (Table 3). Electrical conductivity value ranged from 38.03µS/cm to 128µS/cm, (Table 3). This range is far below the maximum limit of 1000µS/cm, for drinking water quality stipulated by NIS/SON/NAFDAC, (2007). The water in the study is safe to drink in terms of conductivity.

Table 4: Microbiological Properties Compared with Standards

Month	**T. coli(cfu/100ml)**		**E. coli(cfu/100ml)**	
	Mean	Limit	Mean	Limit
May	174	10	75	0
June	168	10	80	0
July	178	10	82	0
August	185	10	84	0
September	181	10	86	0
October	175	10	83	0
November	174	10	78	0
December	171	10	77	0
January	156	10	74	0
February	144	10	73	0
March	138	10	72	0
April	153	10	72	0

Source: (Laboratory Analysis 2013-2014)

The result on microbiological properties of hand dug-well water in the study area revealed that the Total Coliform range from 138 cfu/100 ml to 185 cfu/100 ml, these values are far above the maximum permissible limit of 10cfu/100 ml for safe drinking water quality stipulated by Standard Organization of Nigeria, 2007. The hand dug-well water in the study area is not safe to drink. It was observed that the T. coli were recorded higher in raining season compared to the values obtained in dry season. This could be attributed to the rising water table and entering or seepage of surface run-off flowing into wells that do not have their casing risen high above ground level, and also infiltration of contaminated water into wells that do have cracks on their wall casing. The concentration of E. coli ranged from 72 cfu/100 ml to 86 cfu/100 ml, (Table 4). This value is also far above the maximum permitted level of 0cfu/100ml for safe drinking water quality stipulated by Standard Organization of Nigeria, 2007. The result revealed that the water in the study is not safe for drinking in terms of E. coli and Total Coliform.

Table 5: Treatment of Total Coliform using *Moringa Oleifera*

Month	T. coli	Treatment			Limit cfu/100ml
		10g	20g	30g	10
May	174	84	45	0	10
June	168	85	47	0	10
July	178	88	49	0	10
August	185	90	51	0	10
September	181	88	48	0	10
October	175	83	46	0	10
November	174	83	46	0	10
Decembe2r	171	82	44	0	10
January	156	80	45	0	10
February	144	78	43	0	10
March	138	79	42	0	10
April	153	81	40	0	10

Source: (Laboratory Analysis 2012-2013)

Table 6: Treatment of Escheria Coliform using Moringa Oleifera

Month	E. coli	Treatment			Limit.cfu/100ml
		10g	20g	30g	0
May	75	47	0	0	0
June	80	46	0	0	0
July	82	52	0	0	0
August	84	53	0	0	0
September	86	52	0	0	0
October	83	47	0	0	0
November	78	45	0	0	0
December	77	46	0	0	0
January	74	44	0	0	0
February	73	45	0	0	0
March	72	41	0	0	0
April	72	40	0	0	0

Source: (Laboratory Analysis 2013-2014)

For the untreated raw water the average concentration of Total coliform recorded was 166 cfu/100 ml, while the average concentration of escheria coliform was 78 cfu/100 ml,(Table 5) when 10 g of the powder was applied into the water sample the average concentration of Total coliform dropped to 83.42 cfu/100 ml (Table 5) and E. coli recorded 47 cfu/100 ml(Table 6) when 20 g of the powder was applied the concentration dropped to 45cfu/100 ml**.** E. coli recorded 0 cfu/100 ml, when 30 g of the powder was applied both Total coliform and escheria coliform concentrations drastically dropped to 0 cfu/100ml. The mean concentration of Escheria coliform at controlled level recorded 78 cfu/100 ml , when 10 g of the powder was applied into the water sample the concentration dropped to 46.5 cfu/100 ml, when 20 g and 30 g of the powder were applied it recorded 0cfu/100 ml. The potentials of using *moringa*

oleifera as a treatment substance in the study area is very wide because the tree can be easily grown at the backyards of house hold. The tree does not require advance technology for its growth, it is also drought-tolerant and grows well in rainfalls. By using moringa seeds people will no longer be depending on expensive means originating from the west. Using moringa to purify water replaces chemicals which can be dangerous to human and environment and are expensive. The major limitation/challenge of using the tree is, if the tree is not properly fenced it can be consumed by animals.

Conclusion

This study revealed that the physical properties (Odor, color, taste, TSS, TDS, turbidity and temperature) of the hand dug-well water were found to be within the acceptable limit for safe drinking water quality specified by WHO (2010), NIS/SON/NAFDAC, (2007) throughout the year. The chemical properties (pH, f, cl, Na, Ca, Mg, $SO_{4,}$ $NO_{3,}$ K and conductivity) were also found to be within the acceptable limits for safe drinking water quality earlier specified by WHO (2010), NIS/SON/NAFDAC, (2007). This study also revealed that the microbiological properties (T. coli and E. coli) far above the permitted levels for safe drinking water quality. The moringa powder proportionately reduced the concentration of microbiological contaminants with increasing application rates as a treatment substance, the total coliform population dropped from 166 cfu/100ml (for 0g of moringa powder) to 83 cfu/100ml (for 10g of moringa powder), then 45 cfu/100ml (for 20g of moringa powder), and 0 cfu/l (for 30g of moringa powder). Similarly, the E. coli reduced from 78 cfu/100ml(for 0g of moringa powder) to 47 cfu/100ml (for 10g of moringa powder) and 0 cfu/100ml at both 20 and 30g of moringa powder application rates. **References**

Recommendations

The following recommendations are hereby made:

1. From the results of this study, treatment of hand dug-well water with 30g/l of moringa powder is highly recommended before consumption.
2. It is recommended that hand dug-well water users should be sensitized on the need for prompt sanitation of their hand dug-well surroundings in order to curtail microbiological contamination.

   The State Government should reactivate the existing water treatment plant in the town so that treated water should be made available to the population for their consumption.
3. Awareness should be created among the population on where to site and construct hand dug-well in order to reduce the risk of being contaminated. This will help to minimize water borne diseases.
4. Hand dug-well water users should be educated on how to treat their water with moringa powder before consumption.
5. The Federal and State Governments, as well as International donor Organizations should provide necessary financial support for researchers because these kinds of research work are usually very expensive..

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